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Final Report

March 1987

Development and Implementation of a Rear Vision Device Test Protocol; Volume I, Physical Characteristics Measurement

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16. Abstract

A standardized method for evaluating rear vision devices was developed and implemented. The method consists of the 1) measurement of device physical characteristics including; field of view, magnification, radius of curvature, accommodation demands and reflectance and 2) measurement of simulated-use performance including distance and lane position and motion judgement. Volume I describes the physical characteristics measurement protocol and results for several devices including plane, convex and non-spherical rear view mirrors. Volume II describes the simulated-use protocol and summarizes preliminary simulated-use performance for those measures. Relations between physical characteristics and user performance measures are discussed.

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1.0 INTRODUCTION

1.1 Background and Purpose

In the late 1960's the first sizable scientific evaluations of rear vision systems for motor vehicles were undertaken. Since those original studies, numerous others have followed, each attempting in its own way to evaluate the potential effectiveness of rear vision system characteristics for reducing motor vehicle collisions. A variety of performance measures have been used in laboratory, field-simulation and on-the-road driving situations. These have included target distance judgement error, lane change gap acceptance, motion judgement error, image size distortion and mirror viewing behavior based upon eye movement and other recordings. Today, after almost 20 years, there remains no accepted protocol to which a specific mirror or other rear vision device can be subjected in order to evaluate or estimate its effectiveness in reducing motor vehicle accidents.

Current Federal Motor Vehicle Safety Standards (FMVSS 111) specify minimum standards for rear view systems including certain physical characteristics (e.g., mirror surface curvature) which preclude the use of some recent types of devices such as non-spherical curved mirrors. There is, however, little theoretical and virtually no empirical basis for allowing or disallowing mirrors because of their physical characteristics. The purpose of the present research/development program was to develop a standardized, valid and reliable method for evaluating the accident reduction potential of existing and near-future rear vision systems and to provide a basis for accepting/rejecting devices with unacceptable characteristics.

1.2 Overview of the Method

A method of evaluating rear vision systems which is based on the screening of such systems at successively more sophisticated levels was desired. Ideally, a system would be rejected from further consideration or accepted for further evaluation based upon a quick and inexpensive initial level of evaluation. Subsequent more costly evaluations would be limited to those systems exhibiting the most promise for safety enhancement. A three level measurement/evaluation approach, tiered in terms of incrementing cost and complexity, was envisioned. The three levels were:

I. Measurement/Evaluation of Physical Device Characteristics
   - Field of View
   - Magnification
   - Surface Curvature or Radius of Curvature (ROC)

  - * Accommodations Distance
  - * Reflectance

II. Measurement/Evaluation of Simulated-Use Performance
  - * Use Performance
  - * Observer judgements of threat vehicle position and motion

III. Measurement/Evaluation of Actual On-Road Use Performance

1.3 Organization

Volume I describes the background, development and results of applying a standardized method for measurement of rear vision system physical characteristics. Volume II describes in detail the development, implementation and results of applying a standardized method of evaluating simulated-use of systems. Actual on-road system performance, envisioned as a final level of evaluation was not developed as part of this research due to cost and safety considerations.

1.4 Contents of Volume I

Volume I 1) summarizes the development of the measurement protocol (Section 2.0), 2) describes the general test facility, equipment and methodology (Section 3.0), 3) provides a detailed description of the measurement protocol (Section 4.0), and 5) both summarizes measurement results (Section 5.0) and details measurement results for a variety of common and novel rear view systems (Appendix A).

2.0 DEVELOPMENT OF THE PROTOCOL

2.1 Overview

The purpose of rear vision device characteristics measurement/evaluation is to provide a range of descriptive measures of device characteristics which ultimately can be correlated with simulated-use and/or actual use performance measures. Ideally, these characteristics measures would be used for preliminary screening of rear vision devices as to their acceptability for certain applications and as candidates for more extensive simulated-use tests. Ultimately a set of decision rules might be developed which would be used to accept or reject devices based upon measures such as accommodation distance, magnification, etc.

2.2 Approach

The approach to development of a protocol for measurement of mirror characteristics involved the objectives of 1) low cost, 2) ease of implementation and 3) use of existing procedures and measurement equipment where possible. In all instances the objectives were met, as will be observed in subsequent measurement protocol descriptions.

2.3 Characteristics

Previous studies have identified number of rear vision device characteristics which are relevant to system performance, i.e., safety. These have included:

* Field of View (horizontal and vertical),
* Magnification or size distortion,
* Radius of Curvature of the surface,
* Accommodation Distance, and
* Reflectance.

A general vehicle mock-up, described later in detail, served as a test-bed in which many characteristics measurements as well as simulated-use performance measurements were made. The mock-up and conventional photographic techniques comprised a simple integrated approach. It also maximized the use of the same equipment.

2.4 Characteristics Measurement

Concepts for various characteristics measurements are described here, along with the rational for selecting the specific protocol recommended.

2.4.1 Accommodation

Accommodation demand, i.e., the distance to which the eye must accommodate, is determined by the curvature of a mirrors surface and the distance to the object viewed in the mirror. The distance to which people of various age groups can accommodate is well documented. Therefore, use of large numbers of subjects viewing each mirror to determine the numbers of viewers who can or cannot accommodate to a particular mirror was unnecessary. Accommodation demand or distance, then, was more simply determined by measured eye-to-mirror distance and approximations of radius of curvature measures.

2.4.2 Reflectance

Light measurement is a tedious process requiring great precision and skill. An attempt was made to measure the reflectance of rear view mirrors at various locations on its surface using a Pritchard Photometer placed at the eye point in the vehicle mock-up. This technique, however, was extremely cumbersome and proved quite unreliable in practice. It was, therefore, discarded in favor of the existing standardized SAEJ964a procedure which while lacking the "in-use" geometry is quite simple and reliable.

2.4.3. Radius of Curvature

Two difficulties emerged in the measurement of the radius of curvature across a mirror's surface. First, measures near the edges were desirable but available sphereometers limit the closest measurement to a mirror edge to about .75 inches because of its design. Second, extremely accurate (beyond 1/10,000 inch) measures are necessary to accurately determine radii greater than about 100 inches.

Simple "lens-clocks" commonly used in optometry to measure lens curvature in diopters were tried and found to be far to crude. Subsequently, a depth gauge which permitted measurements to 1/1,000 inch, was mounted above a platform on which a mirror could be moved in x and y dimensions. Repeat measurements, however, were unreliable since only a few ten-thousandths of an inch resulted in several inch differences in ROC. An elaborate and expensive custom platform, and jig gauge to more precisely measure the depth was required to obtain desired reliability and accurate radii determinations.

A third technique was found to be the best compromise between cost, accuracy and reliability. An off-the-shelf, modified, depth gauge with three platform legs was used. Accuracy, reliability and ease of use were satisfactory.

Measures, however, were limited to within .75 inches of mirror edges.

2.4.4 Field of View and Magnification

A method using the vehicle mock-up to locate mirrors and "eyes", or viewing positions, in conjunction with a target grid was used to measure FOV and Magnification. Photographs of a grid viewed via a mirror from left, center and right eye positions provided hard copy of FOV and x y z coordinates for subsequent calculation of angular FOV, if desired. A projected grid permits grid size enlargements, if desired, for unique mirrors.

The hard copy photographs also permit measurement or magnification across a mirror's surface and correlation of magnification with FOV areas on the same photograph.

All magnification measures are expressed as a ratio of percent of a test mirror image size relative to a plane mirror image size for the same area viewed. This approach, therefore, includes in the measures, the effects of oblique viewing of extreme outboard objects. The measures for each eye--left and right--permit comparison of image size for each eye.

Finally, the method permits visual inspection of enlarged photographs of mirror-viewed grid elements for identification of other distortions of image quality which are otherwise difficult to quantify and measure.

3.0 TEST FACILITY AND GENERAL METHODOLOGY

3.1 Test Facility General Description

The facility for testing the various characteristics and performance capabilities of rear vision systems was comprised of a 1) vehicle mock-up with specific eye position(s) and mirror mounting location geometries, 2) photographic and photographic support equipment, 3) projection systems and projection surfaces and 4) variable projectable grid elements including grids and target vehicles (for simulated-use testing).

3.1.1 Test Buck Configuration

The test buck was comprised of a 6 x 6 foot square platform whose surface was calibrated in x and y dimensions and was marked in 1/8 inch increments. The platform provided for the placement of a camera or subject observer's eye position at desired locations simulating vehicle geometries. Also, the platform and affixed mounting hardware permitted installation of rear vision devices at various locations. A foam-board silhouette of a compact vehicle driver compartment was simulated. The test buck is illustrated in Figure 3-1.

3.1.2 Projection Equipment

Various visual stimuli to be viewed by subject observers or photographed were projected via a Kodak Ektagraphic Model III A projector with a BUHL 1.38 "EFL," F:2.5 (35 mm) series 7 wide angle lens. A movable 4 x 8 foot white foam board projection screen was used as a surface for all projections. The locations of the projector and projection screen were described in x, y and z coordinates relative to the "center eye" point for all measurements. The "center eye" point is a eyclopean eye midway between the eyes.

3.1.3 Stimulus Elements

Elements projected onto the screen for viewing included a 4 x 8 foot area grid comprised of 6 inch squares. Within the center of each square was a 3 x 3 inch cross-hair element.

3.1.4 Test Facility Equipment Positioning

The location of each photographic, projection, test device equipment element and viewer center eye position was defined in an x, y, z coordinate reference system. The overall measurement/test facility arrangement is illustrated in Figure 3-1. The x,y, z coordinates of reference points for each equipment element is specified in Table 3-1.

The center eye position in x (forward/rearward) and y (left/right) formed the origin of the coordinate system at

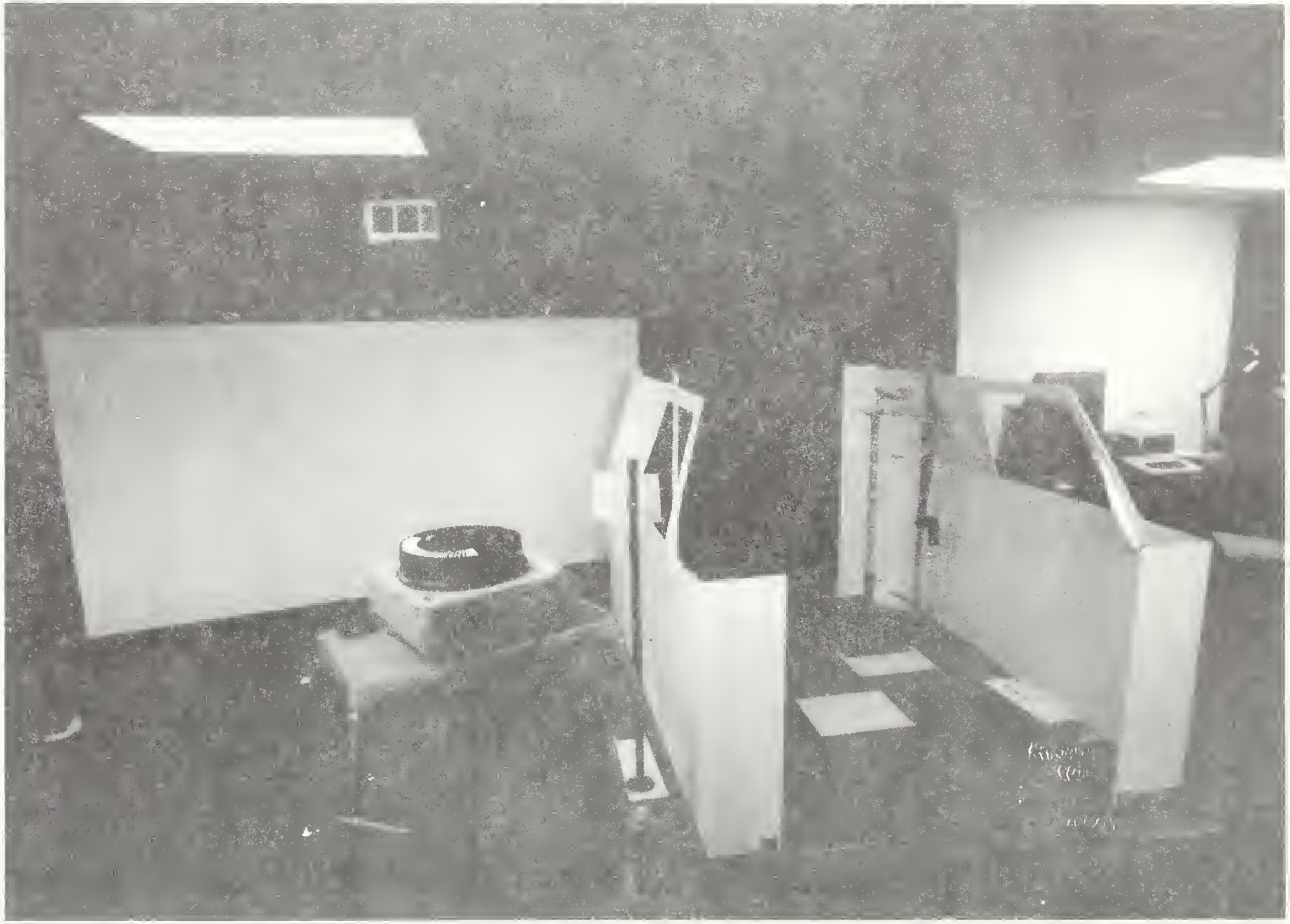


FIGURE 3.1 TEST FACILITY EQUIPMENT ARRANGEMENT

TABLE 3-1
REFERENCE COORDINATES FOR TEST FACILITY SET-UP
(CHARACTERISTICS MEASURES)

		x	y	z
EC	Eye Position Center	0.0	0.0	46.0
RM	Right Mirror Center at Surface	+21.75	+46.5	+36.0
LM	Left Mirror Center at Surface	+21.75	-20.0	+36.0
CM	Center Mirror Center at Surface	+16.0	+13.25	+48.0
PL	Projector Lens Center for Left Screen Projection	+67.0	-63.0	+36.0
PC	Projector Lens Center for Center Screen Projection	+67.0	+13.25	+48.0
PR	Projector Lens Center for Right Screen Projection	+67.0	+91.0	+36.0
SL	Center of 4 x 8 foot Screen at Surface for Left Projection	-38.0	-63.0	+36.0
SC	Center of 4 x 8 foot Screen at Surface for Center Projection	-38.0	0.0	+36.0
SR	Center of 4 x 8 foot Screen at Surface for Right Projection	-38.0	+91.0	+36.0

Notes;

1. All measures in inches.
2. Signs follow SAE procedure for Motor Vehicle Fiducial Marks (SAEJ182a)

ground level (z). The coordinates presented in Table 3-1 define the coordinates for left, center and right mirror systems measured and the coordinates for the projector and projection screen for testing mirrors in left, center and right locations. Equipment arrangement is briefly described below.

3.2 FACILITY SET-UP PROCEDURE

3.2.1 Equipment

In order to set up the test facility for subsequent tests/measurement, the following is required:

- 6 x 6 foot platform with mirror mounting hardware;
- Movable 4 x 8 foot projection screen;
- Ektagraphic projector on adjustable stand;
- 4 foot bubble level;
- String Level;
- Large "T" square;
- Tape measures; and
- 20 x 30 foot enclosed light/sound controlled ventilated space.

3.2.2. Procedures

The procedures for setting-up the facility are as follows.

1) Place test buck platform approximately as shown in Figure 3-2 or 3-3, for left or right side mirror, relative to other equipment. Locate projection screen and projector approximately depending on mirror device location (left, center or right) to be tested.

2) Level platform in both x and y dimensions. Select a location on the platform to serve as the center eye position reference in x and y. Using a "T" square and tape, measure locations of mirror(s) in x and y. Clearly mark lines and points for later reference.

3) Locate the projection screen center as shown in the plan-view of Table 3-1. Level the screen and align its longitudinal axis so that it is perpendicular to the longitudinal axis of the test buck platform. After the center of the screen is properly located and aligned, assure that is is level and vertical using the bubble level.

4) Locate the projector so that a point representing the center of the surface of the lens is at the coordinates shown in Table 3-1. Place the test grid slide in the projector and focus. The projector is to be leveled using the horizontal grid lines. The grid center is then adjusted, using projector base

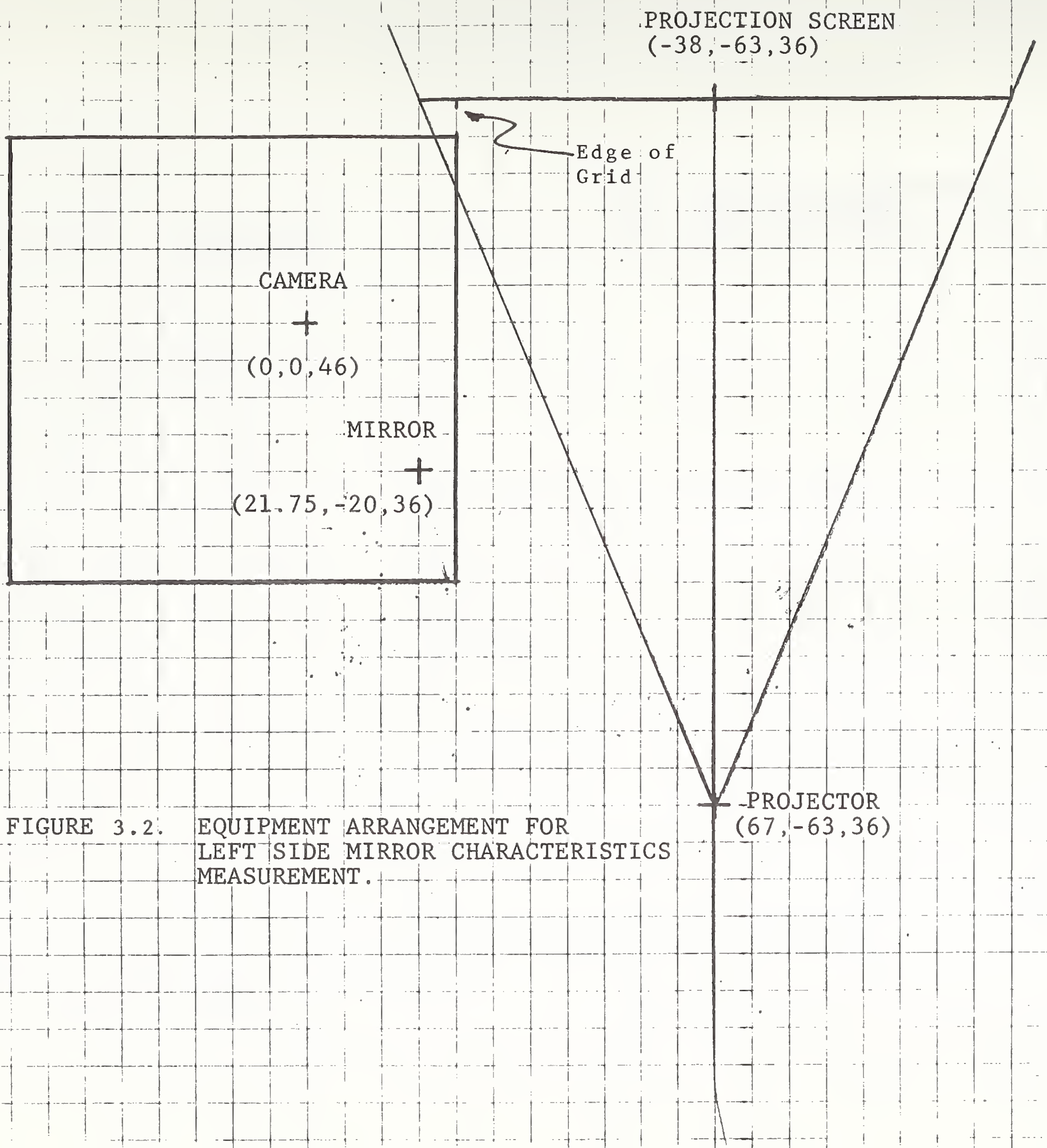


FIGURE 3.2. EQUIPMENT ARRANGEMENT FOR LEFT SIDE MIRROR CHARACTERISTICS MEASUREMENT.

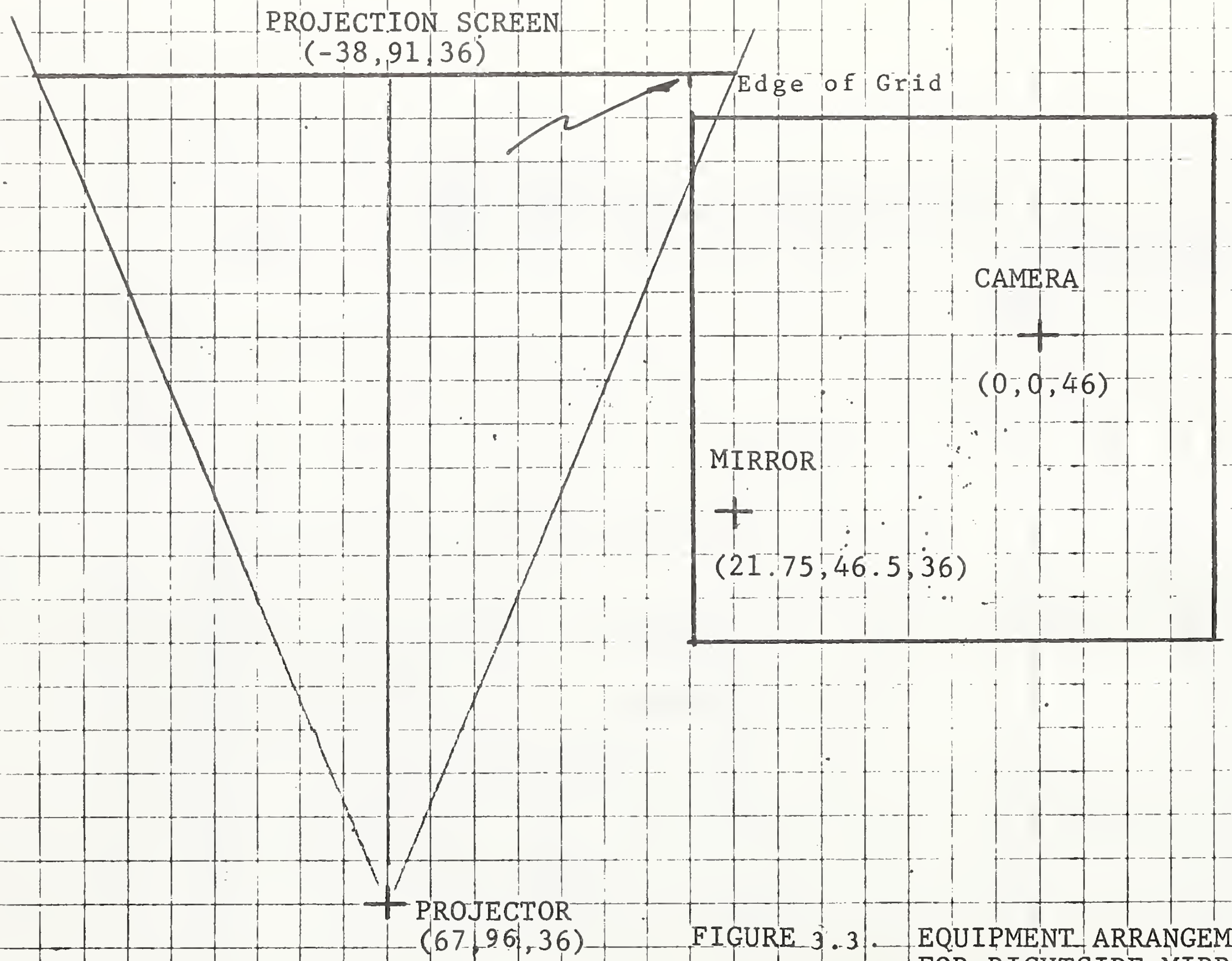


FIGURE 3.3. EQUIPMENT ARRANGEMENT FOR RIGHTSIDE MIRROR CHARACTERISTICS MEASUREMENT.

adjustments, so that it falls on the screen center.

5) Measure 6" grid square projected on screen and adjust projector, if required, so that the grid measures 6 inches square. The Grid is illustrated in Figure 3-4.

6) Finally, assume that all equipment is properly located by checking measurements against Table 3-1 values.

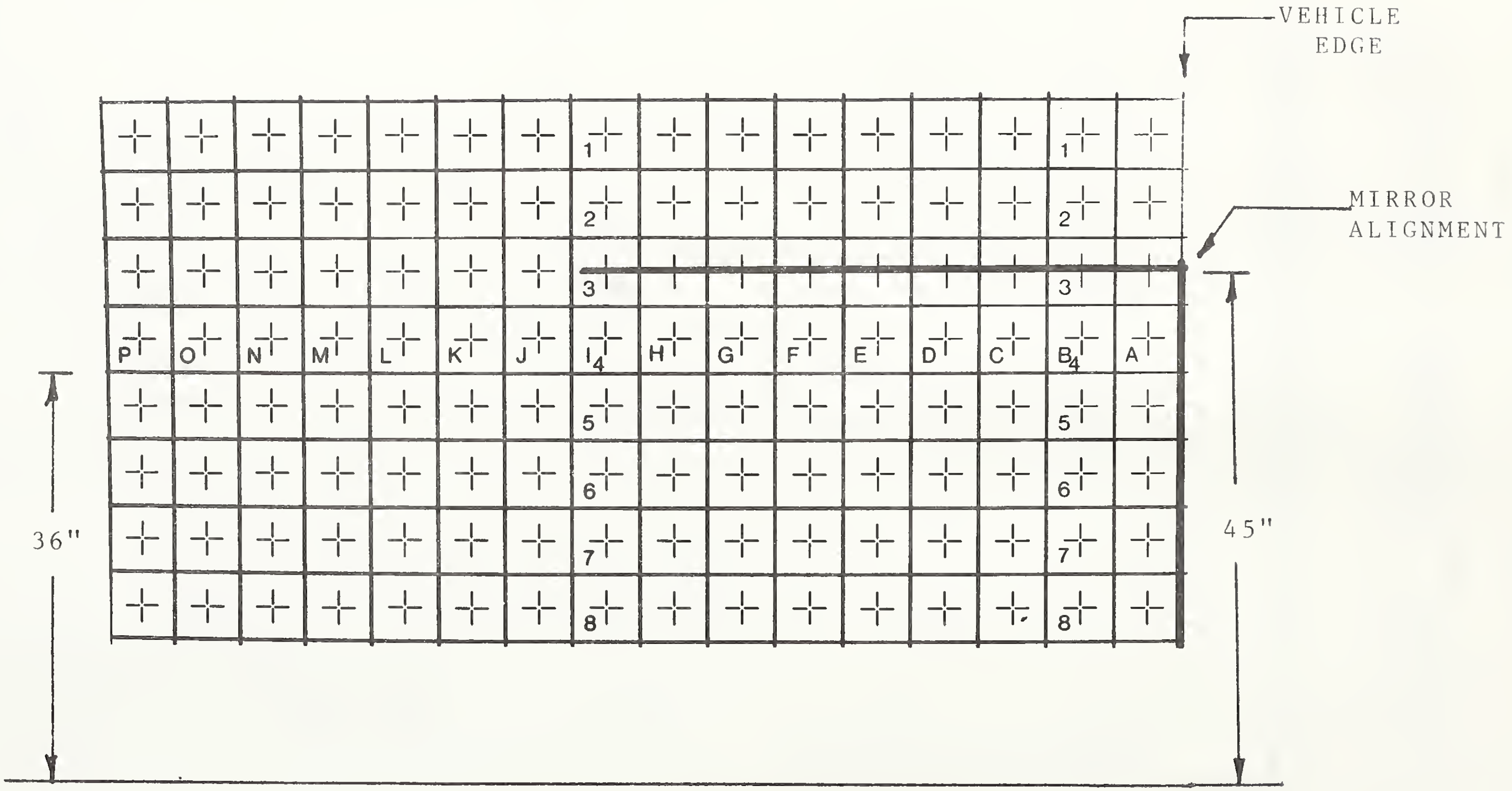


FIGURE 3.4 CHARACTERISTICS MEASUREMENT AND MIRROR ALIGNMENT GRID

4.0 CHARACTERISTICS AND SIMULATED-USE TEST METHODOLOGY AND PROTOCOL

4.0.1 Organization

This section describes the methodology and test protocol for the testing of Rear Vision Device Design Characteristics. Characteristics measured include:

- Field of View (FOV);
- Magnification (MAG);
- Radius of Curvature (ROC);
- Accommodation Distance (ACC); and
- Reflectance (REFL).

4.1 FIELD OF VIEW (FOV) AND MAGNIFICATION MEASUREMENT (PRELIMINARY STEPS)

Both FOV and Magnification measurements of a rear vision device are made from photographs of the test grid. The procedure and equipment for making photographs is described below.

4.1.1 Equipment

The following equipment is required.

- Test facility arranged as described.
- Pentax K1000 SLR Camera with normal 50mm F 1.7 lens.
- Eye positioning platform (EPP)
- Test mirror or device.
- TRI X PAN ASA 400 Film (to be exposed at ASA 800).

4.1.2 Procedure

1. Install EPP (Shown in Figure 4-1), adjust to proper viewing position and level. Install the camera on the EPP and adjust in x, y and z so that the focal plane of the camera is located at the eye position coordinates of Table 3-1. A plumb-line is used to adjust x and y dimensions while z is measured directly.

2. Install mirror at appropriate location. (The procedure described is for a left door mount mirror location). A universal photographic ball-joint and several spacers can be used to attach/adjust the mirror. The front surface of the center of the mirror is to be located as shown in Table 3-1. Other locations, eg. fender, can be used.

3. Adjust camera and rear vision device FOV. With the camera at the appropriate eye location, rotate it horizontally and vertically so that the mirror is in the camera FOV center. Slide the camera to the left eye position (the right eye position is used to align right side

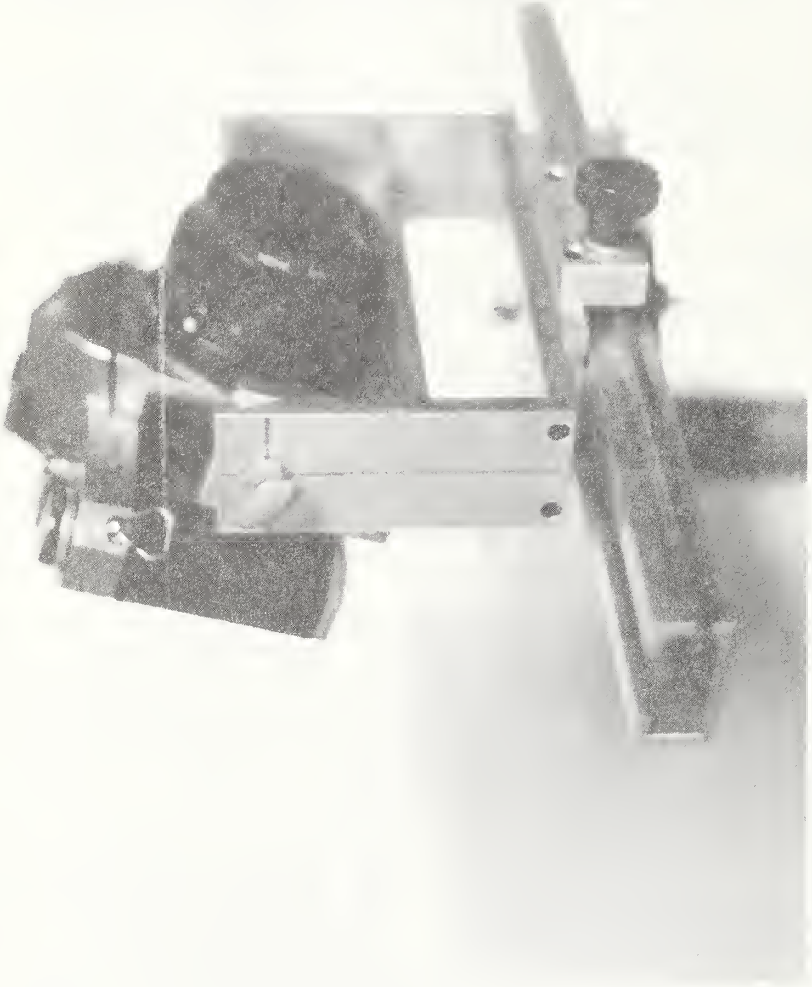


FIGURE 4.1 EYE POSITION PLATFORM

mirrors). While observing the mirror an assistant adjusts the mirror horizontally so that the inner edge of its FOV falls on the inner most grid line representing the vehicle edge. Then adjust the mirror FOV vertically so that the top edge of the mirror views the horizontal grid line 45 inches above the ground. (See Figure 3-1).

4. Tighten mirror adjustment device. It may be desirable to epoxy the mirror adjustment device at this time so that the mirror need not be readjusted for subsequent use.

5. Photograph mirror FOV from left, center and right eye position. Check illumination for camera exposure and F stop. In order to obtain the best-focused print for variable radius of curvature devices several local distances and F stops should be used since depth of field is limited at low levels of illumination and the focal range may be large. It is recommended that several photos be taken so that the single best contrast/focus prints can be used for subsequent analysis. The process is repeated for center and right eye positions by sliding the camera from left to right at 1.25 inch increments from the left eye position.

6. Process film and obtain 8 x 10 or larger enlargements so that the mirror is approximately full scale or larger if desired. These photos are to be used for magnification and FOV measurement.

4.2 FIELD OF VIEW (FOV) MEASUREMENT

4.2.1 Purpose

The purpose of FOV measurement is to determine the test rear vision device FOV grid area which is visible to either and/or both eyes.

4.2.2 Equipment

Enlarged photograph of FOV grid for both left and right eye position. (See Figure 4-2 and 4-3)

4.2.3 Procedure

4.2.3.1 Examine left and right eye position photographs of the FOV grid and plot the perimeter of the grid points visible to each eye. See Figure 4-4 for an example.

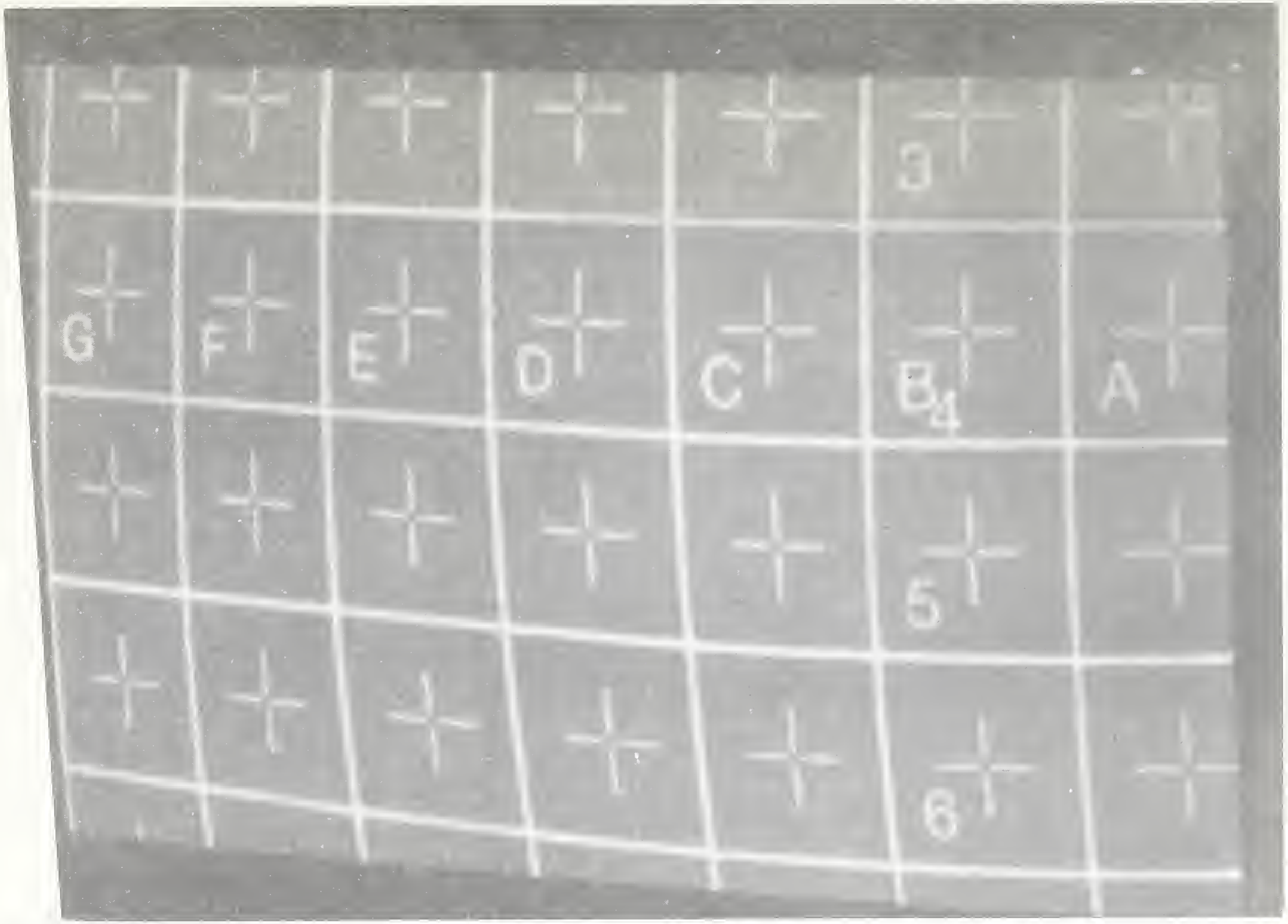


FIGURE 4-2

Convex Mirror FOV and Grid
(Left Eye)

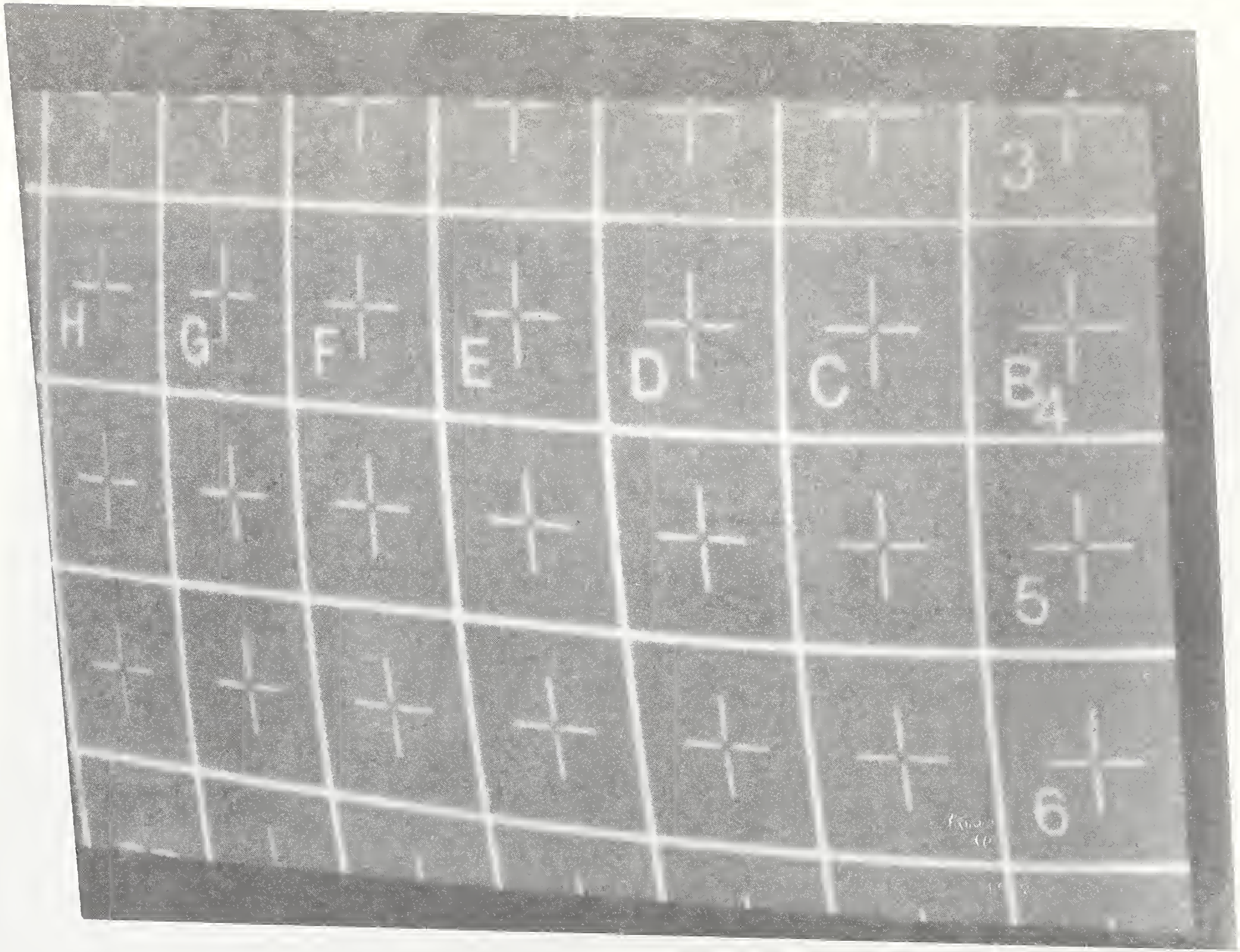


FIGURE 4-3

Convex Mirror FOV and Grid
(Right Eye)

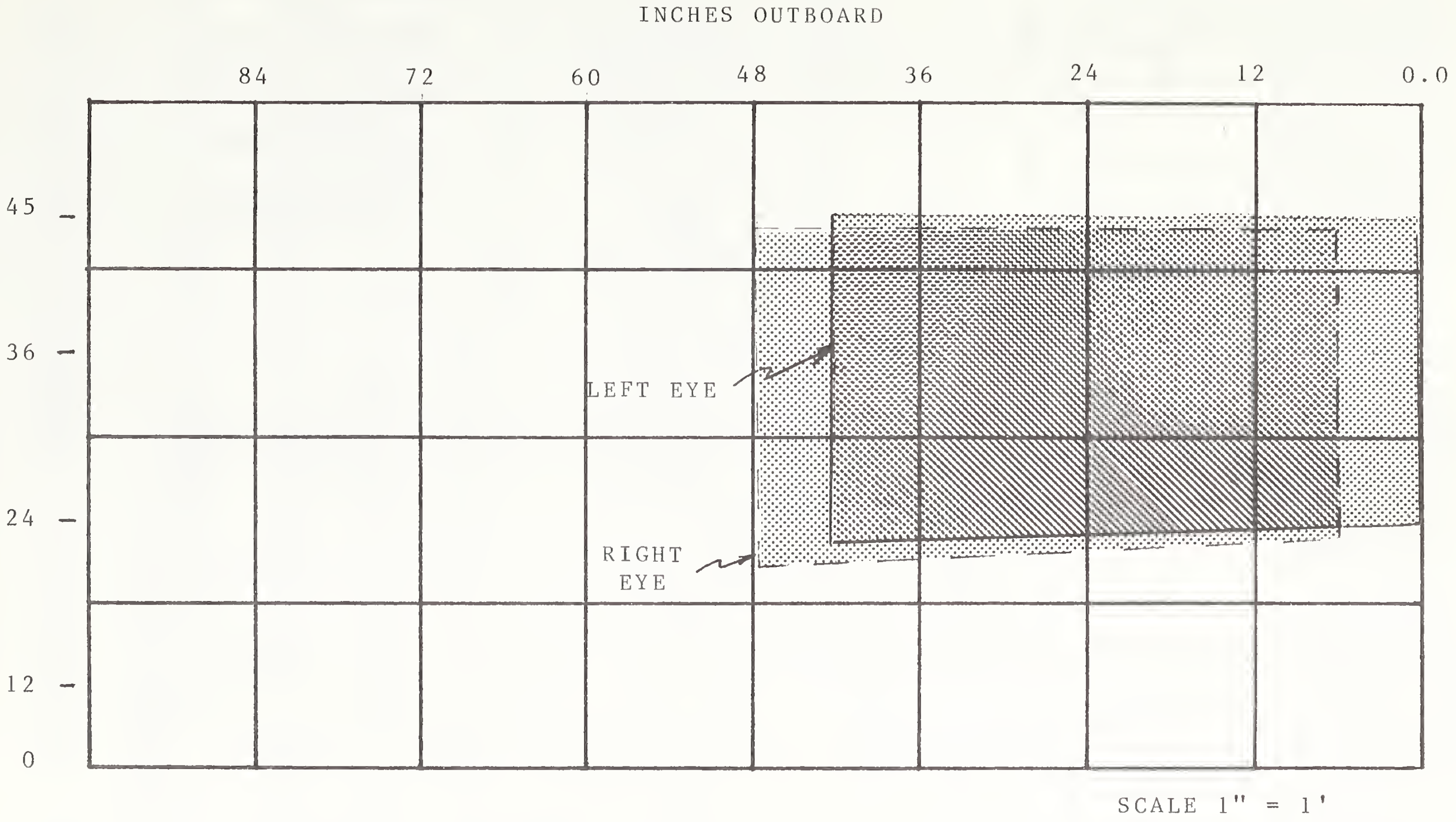


FIGURE 4.4 6.5 X 4.0 INCH 40" ROC MIRROR FOV ON DRIVER SIDE

4.3 MAGNIFICATION MEASUREMENT

4.3.1 Purpose

The purpose of magnification measurement is to determine the horizontal and vertical image size of the test rear vision device relative to that of a plane mirror, across the surface of the device. Magnification is the ratio of test device image size, in a specific target grid area viewed, to plane mirror image size in the same viewed grid area.

4.3.2 Equipment

The following equipment is required for magnification measurement:

- Enlarged photo prints of FOV grid for left and right eye.
- Magnifier with reticle scaled in .1mm or equivalent increments.
- Recording forms
- Tabled values generated for corrections.

4.3.3 Procedure

4.3.3.1 Obtain high-contrast quality 8 x "10 " enlargements of left and right eye photographs of the FOV grid.

4.3.3.2 Measure length of known object (eg. near edge of mirror mounting frame) in photo to the nearest 1mm. Determine the ratio of the photo enlargement to actual size (eg. 140mm : 152mm). Determine the appropriate correction (eg. 152/140 = 1.086) to be applied to subsequent measures to correct for photographic image enlargement size discrepancy.

4.3.3.3 Measure the horizontal distance between grid cell vertical lines and the vertical distance between horizontal grid lines, using the magnifier/reticle, to .1mm. Since some devices may present images which are rotated, measures are to be made at the midpoint of the cell, as defined by the cell cross-hair element and along the direction of the element. Repeat horizontal and vertical measures for all cells visible on the photograph for left and right eye positions. Record measurements for each eye and orientation (horizontal and vertical) on a separate recording form (see Form M-1, Table 4-1).

4.3.3.4 Correct measurements on Form M-1 by applying the photo enlargement correction determined in 4.3.3.2 above to bring measures to the proper scale.

4.3.3.5 Relate test mirror image size to plane mirror image size. Magnification of image size of each grid cell for a

TABLE 4.1 MAGNIFICATION RECORDING FORM (M-1)

DEVICE DESCRIPTION Non-Spherical (V)

DEVICE DIMENSIONS 6.5 X 4.5

EYE REFERENCE Right Eye

MAGN. MEASURE Horizontal

DATE MEASURED

MEASURED BY

NOTES Uncorrected measure from photo

HORIZONTAL GRID CELL

VERTICAL GRID CELL

	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
1																
2																
3																
4														40.8 mm		
5																
6																
7																
8																

TABLE 4.1 MAGNIFICATION RECORDING FORM (M-1) -Continued

DEVICE DESCRIPTION Non-Spherical (V)

DEVICE DIMENSIONS

EYE REFERENCE Right Eye

MAGN. MEASURE Horizontal

DATE MEASURED

MEASURED BY

NOTES Photo Scale Correction

(.819x) applied

HORIZONTAL GRID CELL

VERTICAL GRID CELL	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
1																
2																
3																
4														33.4 mm		
5																
6																
7																
8																

TABLE 4.1 MAGNIFICATION RECORDING FORM (M-1) - Continued

DEVICE DESCRIPTION Non-Spherical (V)
DEVICE DIMENSIONS
EYE REFERENCE Right Eye
MAGN. MEASURE Horizontal
DATE MEASURED
MEASURED BY

NOTES Corrected Magnification (Ratio of Test Cell Size to Plane Mirror Cell Size)

HORIZONTAL GRID CELL

VERTICAL GRID CELL	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
1																
2																
3																
4														.65		
5																
6																
7																
8																

test mirror is expressed relative to the image size of a plane mirror for that same grid cell. Since the image size becomes smaller as a function of the increased viewing distance for further outboard objects (or grid cells), i.e., visual angle subtended by a grid cell decreases at increased viewing angles, the plane mirror image size for each grid cell needs to be determined. Grid cells of a plane mirror, however, beyond B or C, cannot be measured directly, since they are generally not visible in limited plane the mirror FOV. Therefore, they must be calculated.

STEPS

1) First calculate the horizontal visual angle subtended by cell A (see grid) using the viewing distance to the screen via the mirror (eye to mirror plus mirror to screen). This is 92 inches for the left door mount mirror described in tests. The visual angle of cell A is 3.72 degrees.

2) Compute the horizontal visual angle of cells B-P. The visual angle of cell H is 3.00 degrees, for example.

3) Calculate the percent decrease in visual angle for each cell relative to cell A. Cell H, for example, is 80.6 percent of A. Construct a table of decreased horizontal visual angle for each cell for each mirror/eye position geometry of interest.

4) Apply these "corrections" to plane mirror measurements.
If a plane mirror cell A measured 52mm, then the calculated reference image sizes for cells B-P are as shown below;

Cell Location	Corrected Size (mm) (left door location)
A	52.0
B	51.7
C	51.2
D	49.6
E	47.8
F	46.1
G	45.0
H	41.9
.	.
P	26.0

Note that the image size of cell P, if it were visible, would be only 50% of that of cell A.

5) Repeat the above procedure for each mirror mounting location since a new plane mirror reference image size

for each device/test location is required.

6) No corrections to vertical cell sizes are necessary if the vertical viewing angle to visible cells is small.

4.3.3.6 Record the results of 4.3.3.5 above on Form M-1, with proper notation as to corrections which have been made in the notes section.

4.3.3.7 Plot magnification on grid paper for left and right eyes for horizontal and vertical grid cell elements.

4.3.3.8 Sample Magnification Measurement

Figure 4-5 illustrates the grid imagery of a non-spherical curved mirror as viewed by the right eye. Grid cell C-4 (C=Vertical, 4= Horizontal) is measured as an example.

Step 1

Measure horizontal and vertical dimensions of cell with magnifier/reticle aligned along the cross-hair element. Both dimensions (H & V) measure 40.8 mm. Enter measures in appropriate cell of form M-1.

Step 2

Determine correction for photo enlargement by measuring vertical height of mirror mounting plate at near edge. Vertical height measures 155 mm. The actual vertical height of the plate edge is 5 inches or 127 mm. Thus, the measures in Step 1 are "corrected" by multiplying each by .819 or 127/155. New values of 33.4 mm (H and V) are entered on Form M-1.

Step 3

Correct measures above so that they represent the ratio of test mirror image size to plane mirror image size, using values described in 4.3.3.5.

Step 4

Repeat calculations for all grid cells for each eye position (left and right). Tables 4.2-4.5 show the horizontal and vertical magnification for left and right eye positions for each grid cell visible by a 40 inch ROC convex mirror.

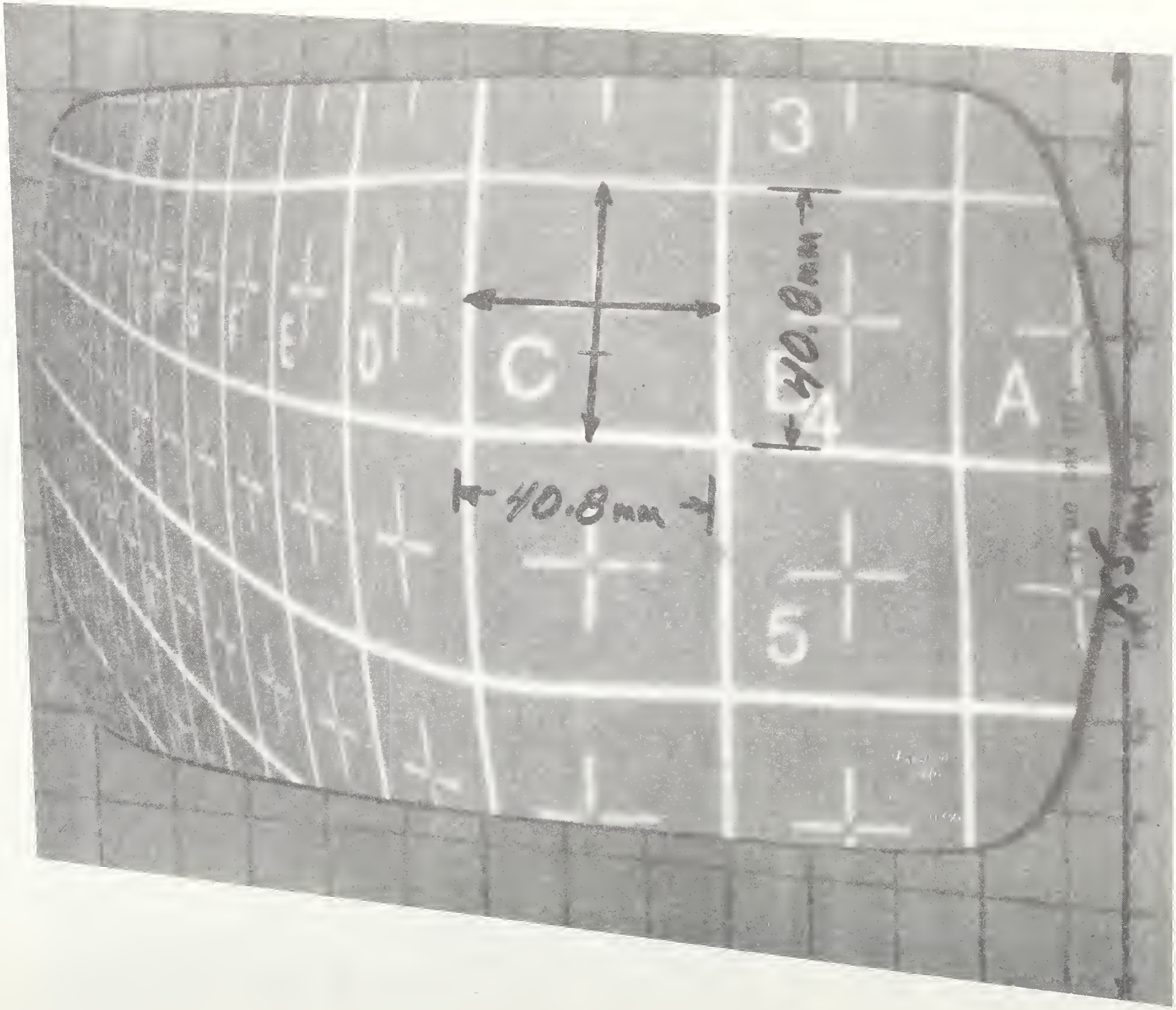


FIGURE 4.5 MAGNIFICATION MEASURMENT OF MIRROR GRID CELLS

TABLE 4.2 MAGNIFICATION RECORDING FORM (M-1)

DEVICE DESCRIPTION Convex 40"

DEVICE DIMENSIONS 6.5 X 4.0

EYE REFERENCE Left

MAGN. MEASURE Horizontal

DATE MEASURED

MEASURED BY

NOTES Left Eye

Horizontal Magnification

HORIZONTAL GRID CELL

VERTICAL GRID CELL	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
1																
2																
3										.38	.39	.42	.45	.46	.47	–
4										.38	.39	.42	.46	.46	.47	–
5										.39	.40	.44	.46	.45	.47	–
6										.39	.41	.45	.46	.44	.46	–
7																
8																

TABLE 4.3 MAGNIFICATION RECORDING FORM (M-1)

DEVICE DESCRIPTION Convex 40"
DEVICE DIMENSIONS 6.5 X 4.0
EYE REFERENCE Right
MAGN. MEASURE Horizontal
DATE MEASURED
MEASURED BY

NOTES Right Eye
Horizontal Magnification

HORIZONTAL GRID CELL

VERTICAL GRID CELL	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
1																
2																
3									.35	.37	.40	.42	.46	.45	.48	—
4									.35	.38	.40	.42	.45	.43	.48	—
5									.37	.38	.41	.44	.45	.45	.48	—
6									.37	.38	.42	.44	.42	.45	.48	—
7																
8																

TABLE 4.4 MAGNIFICATION RECORDING FORM (M-1)

DEVICE DESCRIPTION Convex 40"

DEVICE DIMENSIONS 6.5 X 4.0

EYE REFERENCE Left

MAGN. MEASURE Vertical

DATE MEASURED

MEASURED BY

NOTES Left Eye

Vertical Magnification

HORIZONTAL GRID CELL

VERTICAL GRID CELL	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
1																
2																
3																
4										.55	.54	.53	.53	.52	.51	.51
5										.54	.53	.52	.51	.49	.49	.51
6										.54	.53	.53	.52	.49	.51	.51
7																
8																

TABLE 4.5 MAGNIFICATION RECORDING FORM (M-1)

DEVICE DESCRIPTION Convex 40"
DEVICE DIMENSIONS 6.5 X 4.0
EYE REFERENCE Right
MAGN MEASURE Vertical
DATE MEASURED
MEASURED BY

NOTES Right Eye
Vertical Magnification

HORIZONTAL GRID CELL

VERTICAL GRID CELL	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
1																
2																
3																
4									.58	.57	.55	.55	.54	.52	.51	
5									.58	.57	.53	.53	.52	.51	.51	
6									.55	.54	.54	.54	.52	.51	.51	
7																
8																

4.4 RADIUS OF CURVATURE MEASUREMENT (ROC)

4.4.1 Purpose

The purpose of ROC measurement is to determine the curvature of a test rear vision device across its surface vertically and horizontally at several points so as to describe the radius as a function of horizontal and vertical location across the surface.

4.4.2 Equipment

- Test rear vision device
- Sphereometer (Starrett, Model 655-611, See Figure 4-6)
- Recording forms

4.4.3 Procedure

4.4.3.1 Determine the horizontal and vertical center of the device image surface. Then, using an appropriate marking device eg. grease pencil, draw vertical and horizontal lines at .5 inch increments across the surface in the horizontal and vertical dimensions. Trace the outline of the mirror onto Form R-1 to illustrate measurement coordinates (see Table 4.6).

4.4.3.2 Determine the sphereometer "zero" reading for a known flat surface obtaining a dial reading, eg.1508 inch. Record this reading on Form R-2 (see Table 4-7) to be used later to correct subsequent dial readings.

4.4.3.3 Measure ROC of test device. Carefully place the measuring post of the sphereometer on the device surface at the intersection of each of the horizontal and vertical lines, keeping the exterior posts along the vertical line to measure vertical curvature and along the horizontal line to measure horizontal curvature.

When the sphereometer is in place, read the dial to .0001 inch and record in the appropriate cell of Form R-2. Take a dial reading measurement vertically and horizontally at the intersection of each vertical/horizontal line drawn on the surface. Record all dial readings.

4.4.3.4 Correct dial readings by subtracting the "zero" correction dial reading from 4.1.3.2 above from each vertical and horizontal dial reading on Form R-2. Record the results on Form R-2 with correction notations (see Table 4.8)

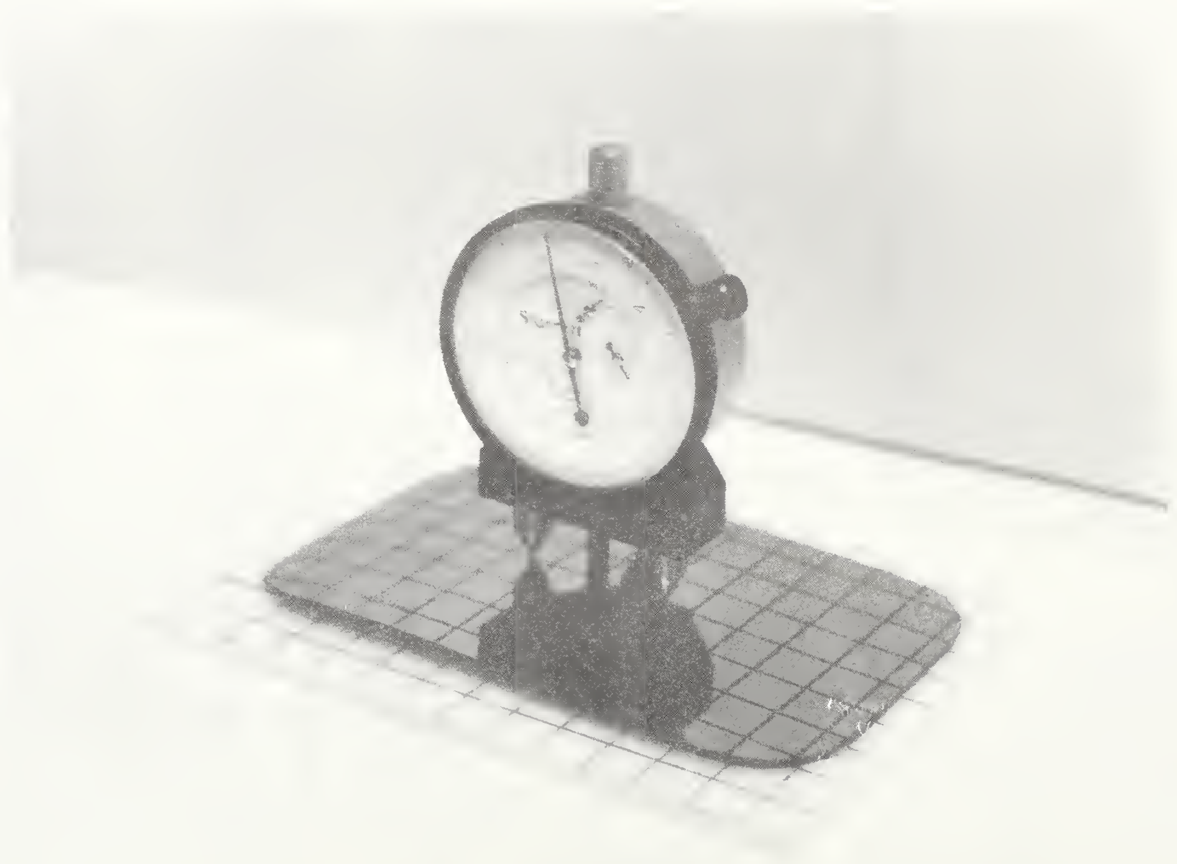


FIGURE 4-6 SPHEROMETER IN POSITION TO MEASURE RADIUS

TABLE 4.6
RADIUS MEASUREMENT REFERENCE GRID (R-1)

DEVICE I.D. 40" ROC MIRROR

DATE 1/16/86

MEASURED BY____________________

NOTES____________________

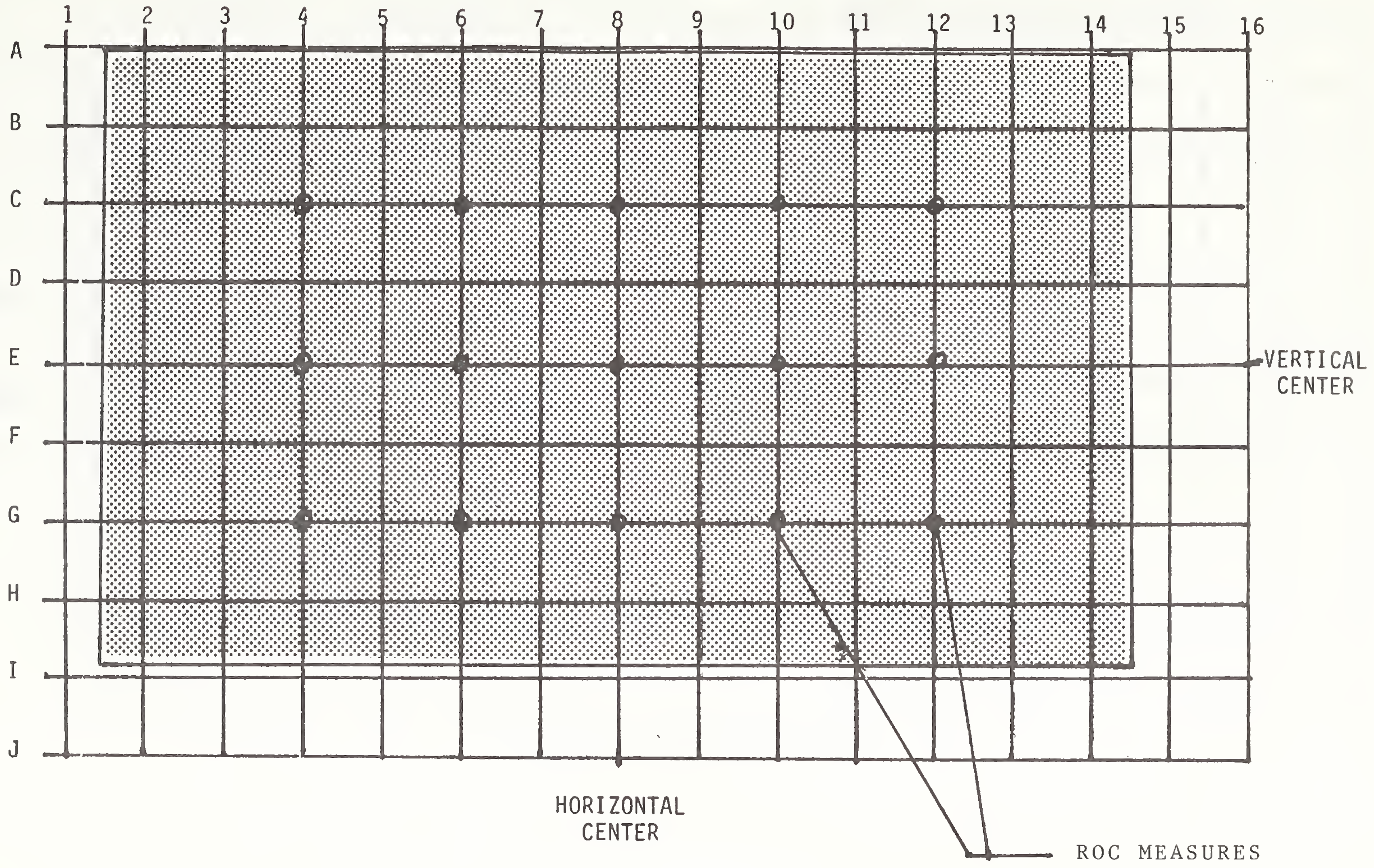


TABLE 4.7 RADIUS MEASUREMENT FORM (R-2)

HORIZONTAL GRID INTERSECTION

VERTICAL GRID INTERSECTION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
A																
B		H/V														
C				1783/1629												
D																
E						1821/1749										
F																
G																
H																
I																
J																

DEVICE I.D. CONVEX 40"

MEASURED BY ____________

DATE ____________

TYPE MEASURE/CALCULATION Uncorrected dial reading (Actual)

NOTES CORRECTION TO DIAL READING = -.1560 in.

(Readings in .0001)

TABLE 4.8 RADIUS MEASUREMENT FORM (R-2)

HORIZONTAL GRID INTERSECTION

VERTICAL GRID INTERSECTION

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
A																
B																
C				223/069												
D																
E						261/189										
F																
G																
H																
I																
J																

DEVICE I.D. CONVEX 40"

MEASURED BY

DATE

TYPE MEASURE/CALCULATION "Corrected"

Dial Reading

NOTES Correction of -.1560
applied

(Dial Reading in .0001)

TABLE 4.9 RADIUS MEASUREMENT FORM (R-2)

HORIZONTAL GRID INTERSECTION

VERTICAL GRID INTERSECTION

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
A																
B																
C				12/40												
D																
E						11/15										
F																
G																
H																
I																
J																

DEVICE I.D. Convex 40"

MEASURED BY ____________

DATE ____________

TYPE MEASURE/CALCULATION ROC in inches

NOTES ROC from conversion
Table

4.4.3.5 Determine the ROC for each dial reading using values of Table 4.12 and record on Form R-2 (see Table 4.9) with appropriate notation.

4.4.3.6 Plot ROC for horizontal and vertical measures for each (H-V) location position measured. Tables 4.10 and 4.11 show the horizontal and vertical radius measurements (in inches) across the surface of a 40 inch ROC convex mirror.

TABLE 4.10 RADIUS OF CURVATURE MEASUREMENT FORM

DEVICE Convex 40"

MEASURED BY __________

MEASUREMENT Horizontal Radius (in)

DATE __________

HORIZONTAL DISTANCE FROM CENTER (IN.)

VERTICAL DISTANCE FROM CENTER (IN.)	-4.0	-3.5	-3.0	-2.5	-2.0	-1.5	-1.0	-.5	0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
2.5																	
2.0																	
1.5																	
1.0					37		36		38		39		36				
.5																	
0					36		36		37		37		34				
-.5																	
-1.0					37		38		39		36		34				
-1.5																	
-2.0																	
-2.5																	

INSIDE MIRROR EDGE

TABLE 4.11 RADIUS OF CURVATURE MEASUREMENT FORM

DEVICE Convex 40"

MEASURED BY

MEASUREMENT Vertical Radius (in.)

DATE

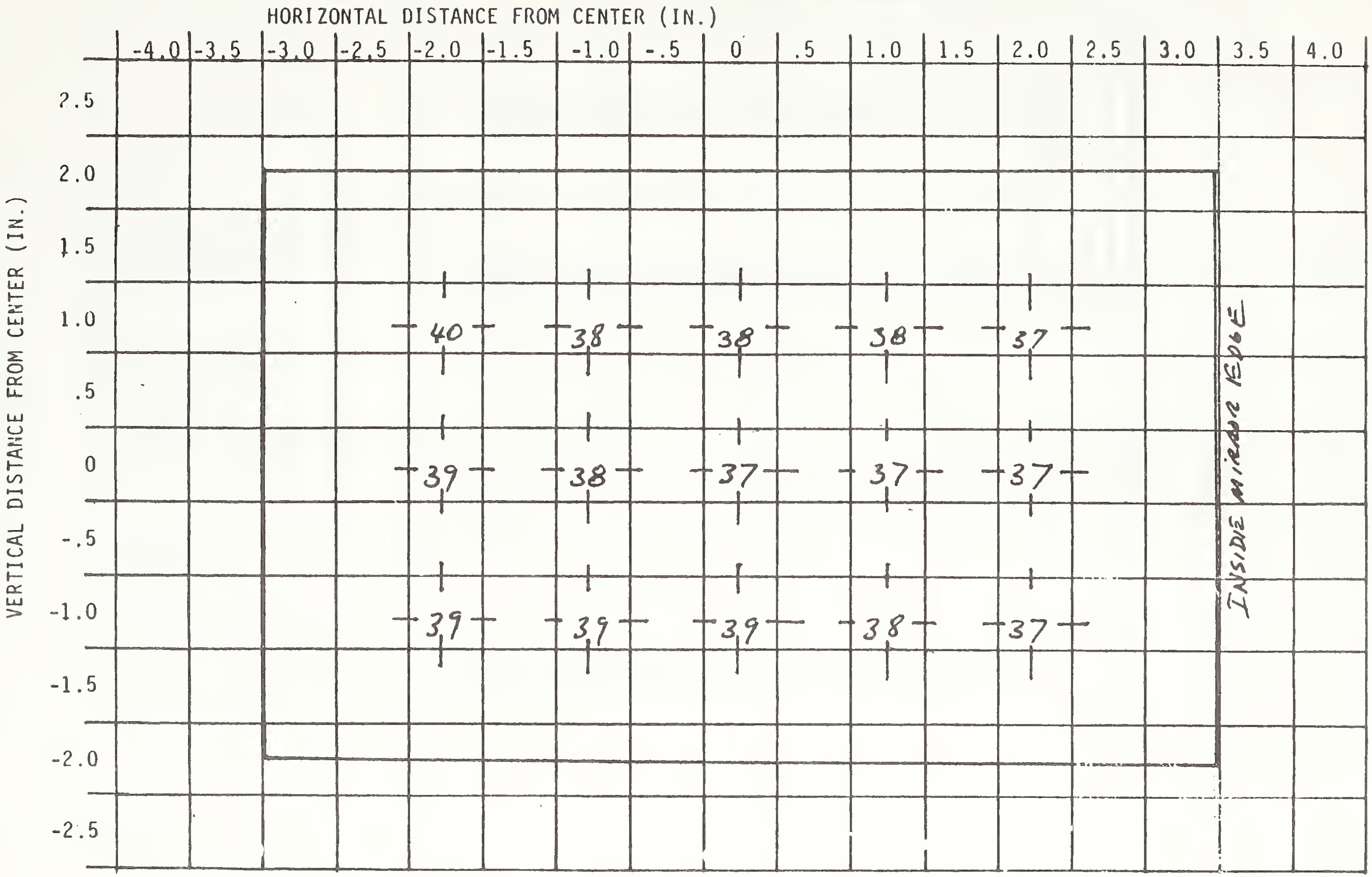


TABLE 4.12 CONVERSION FROM DIAL READING TO ROC (Adapted from FMVSS 111)

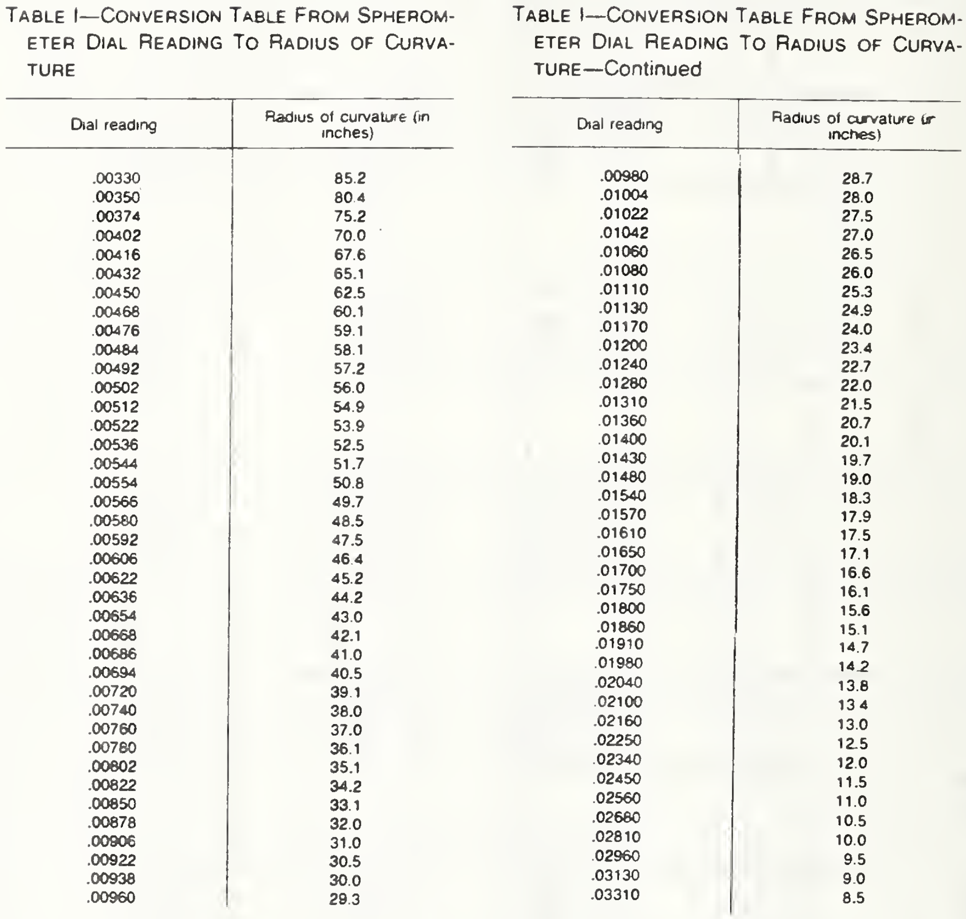


TABLE I—CONVERSION TABLE FROM SPHEROMETER DIAL READING TO RADIUS OF CURVATURE

Dial reading	Radius of curvature (in inches)
.00330	85.2
.00350	80.4
.00374	75.2
.00402	70.0
.00416	67.6
.00432	65.1
.00450	62.5
.00468	60.1
.00476	59.1
.00484	58.1
.00492	57.2
.00502	56.0
.00512	54.9
.00522	53.9
.00536	52.5
.00544	51.7
.00554	50.8
.00566	49.7
.00580	48.5
.00592	47.5
.00606	46.4
.00622	45.2
.00636	44.2
.00654	43.0
.00668	42.1
.00686	41.0
.00694	40.5
.00720	39.1
.00740	38.0
.00760	37.0
.00780	36.1
.00802	35.1
.00822	34.2
.00850	33.1
.00878	32.0
.00906	31.0
.00922	30.5
.00938	30.0
.00960	29.3
.00980	28.7
.01004	28.0
.01022	27.5
.01042	27.0
.01060	26.5
.01080	26.0
.01110	25.3
.01130	24.9
.01170	24.0
.01200	23.4
.01240	22.7
.01280	22.0
.01310	21.5
.01360	20.7
.01400	20.1
.01430	19.7
.01480	19.0
.01540	18.3
.01570	17.9
.01610	17.5
.01650	17.1
.01700	16.6
.01750	16.1
.01800	15.6
.01860	15.1
.01910	14.7
.01980	14.2
.02040	13.8
.02100	13.4
.02160	13.0
.02250	12.5
.02340	12.0
.02450	11.5
.02560	11.0
.02680	10.5
.02810	10.0
.02960	9.5
.03130	9.0
.03310	8.5

4.5. ACCOMMODATION DISTANCE DETERMINATION

4.5.1 Purpose

Accommodation distance is the nearest distance from the eye to an object at which the image can be brought into focus on the retina. The accommodation distance to a mirror is the distance from the eye to the focal point or plane. The procedure for calculating the required accommodation distance is described below for plane and curved mirrors.

4.5.2 Method

4.5.2.1 Plane Mirrors

Accommodation demand for a plane mirror image is equal to eye-mirror-object distance. Since other vehicles to be viewed are generally at a distance greater than 2-3 meters, the limit for the population of older drivers, accommodation to plane mirror images is generally of little interest.

4.5.2.2. Curved Mirrors

Accommodation demand for curved mirrors, however, is considerably less being the eye-mirror distance plus the mirror focal distance. Calculation of accommodation demand differs for spherical and non-spherical mirrors.

4.5.2.2.1 Spherical Mirrors

The accommodation distance for spherical mirrors is approximated by the formula: $D_{ACC} = D_{EM} + 1/2\ R$

D_{ACC} = Accommodation Distance
Where D_{EM} = Eye to Mirror distance,
R = Mirror radius curvature

For example, the required accommodation distance for a 40 inch ROC spherical mirror located 32 inches from the eye is 32 + 20 = 52 inches.

4.5.2.2.2 Non-Spherical Curved Mirror

Non-spherical curved mirrors, by definition, have a different radius of curvature across the mirror surface and thus require varying accommodation distances. The accommodation distances can be approximated by using the formula of 4.5.2.2.1 above, given the specific ROC of the surface upon which the viewed image is located. For example, a non-spherical curved mirror whose surface ROC ranges from (flat) to 6 inches at a 32 inch distance to the eye would require accommodation over a range from 64 to 35 inches.

4.6 REFLECTANCE MEASUREMENT

4.6.1 Purpose

The purpose of reflectance measurement is to determine the percentage incident light reflected from the surface of a rear view mirror.

4.6.2 Method

The method used to measure reflectance is SAE Standard J964a--Test Procedure for Determining Reflectivity of Rear View Mirrors. The procedure involves the use of a 1) standardized collimated light source, 2) photo receptor and 3) reflectance meter reading percent reflectance. Curved mirrors require the use of an integrating sphere.

4.6.3 Results

In order to verify the method, one non-spherical curved mirror, known as the "Mahon" mirror was tested by the Donnelly Corporation. The reflectance standard used is traceable to NBS Standard 2003C. The mirror reflectance was found to be 48.4 percent ± 0.7 based upon the NBS Standard accuracy of ± .5 percent.

5.0 CHARACTERISTICS MEASUREMENT SUMMARY

5.1 Summary of All Measures

The measurement characteristics of four mirrors, mounted on left and right side door locations are presented in Table 5.1. Detailed measures for all mirrors are presented in Appendix A. Measures include 1) physical size, 2) Field of View, 3) Magnification, 4) Radius of Curvature, and 5) Accommodation Distance. Horizontal FOV is expressed in degrees as well as lateral outboard distance visible. FOV is correlated with Simulated-use Figure of Merit scores described in Volume II.

5.2 Radius of Curvature

Figure 5.1 illustrates the horizontal radius of curvature of the four mirrors across their surface. All radii shown are referenced to the horizontal center of each mirror.

5.3 Magnification

Figure 5.2 illustrates, for the non-spherical (V) mirror, the magnification of each grid cell for left and right eye locations. Magnification or image size difference between the two eyes is at its maximum in horizontal grid cell "D". Images in this grid cell are approximately 40% narrower when viewed by the left eye relative to that viewed by the right eye. Fusing these two disparate images into a single clear image was at best difficult and impossible for many mirror users. Left/right eye image size differences for other mirrors tested were small.

TABLE 5.1 SUMMARY OF MEASURED MIRROR CHARACTERISTICS

NAME	PLANE	PLANE	40" ROC	40" ROC	"V"	"V"
TYPE	FLAT	FLAT	CURVED	CURVED	CURVED	CURVED
SPEC. CHARACT.	FLAT	FLAT	SPHER	SPHER	NON-SPH	NON-SPH
SIZE (IN.)	4.0 X 6.5	4.0 X 6.5	4.0 X 6.5	4.0 X 6.5	4.0 X 6.5	4.0 X 6.5
MOUNT LOCAT.	LT DOOR	RT DOOR	LT DOOR	RT DOOR	LT DOOR	RT DOOR
FIELD OF VIEW *						
HORIZ.	22.5" (14)**	14" (7)	48" (31)	36" (20)	78" (49)	72" (42)
VERT.	12"	9"	23"	19"	18" - 30"	15"-22"
MAGNIFICATION						
HORIZ.	1	1	0.43	0.43	.06-.60	.06-.60
VERT.	1	1	0.53	0.53	.50-.65	.50-.65
RADIUS						
HORIZ.	-	-	37"	37"	6"- 60"	6"-60"
VERT.	-	-	37"	37"	28"-71"	28"-71"
ACCOM. DIST.			52"	68"	35-62"	51-78"
REFLECTANCE	TBD	TBD	TBD	TBD	TBD	TBD

* AT 60" BEHIND MIRROR SURFACE

** APPROXIMATE FOV IN DEGREES

TABLE 5.1 SUMMARY OF MEASURED MIRROR CHARACTERISTICS (CONTINUED)

NAME	"Z"	"Z"	20"ROC	"K"
TYPE	CURVED	CURVED	CURVED	FLAT/CURV.
SPEC. CHAR.	NON-SPH	NON-SPH	SPHER	FLAT/SPHER
SIZE	3.5 X 6.5	3.5 X 6.5	3.6 X 4.4	3.7 X 4.1 / 3.7 X 2.0
MOUNT LOC.	LT DOOR	RT DOOR	RT DOOR	RT DOOR
FIELD OF VIEW *				
HORIZ.	31" (23)	24" (15)	38"	36"
VERT.	11"	9"	27"	36"
MAGNIFICATION **				
HORIZ.	.27-.98	.27-.98	0.24	1.0/.13
VERT.	.57-.94	.57-.94	0.24	1.0/.13
RADIUS				
HORIZ.	30"-FLAT	30"-FLAT	20"	10"
VERT.	37"-FLAT	37"-FLAT	20"	10"
ACCOM. DIST.	47-96"	63-96"	58"	53"
REFLECTANCE	TBD	TBD	TBD	TBD

* AT 60" BEHIND MIRROR SURFACE

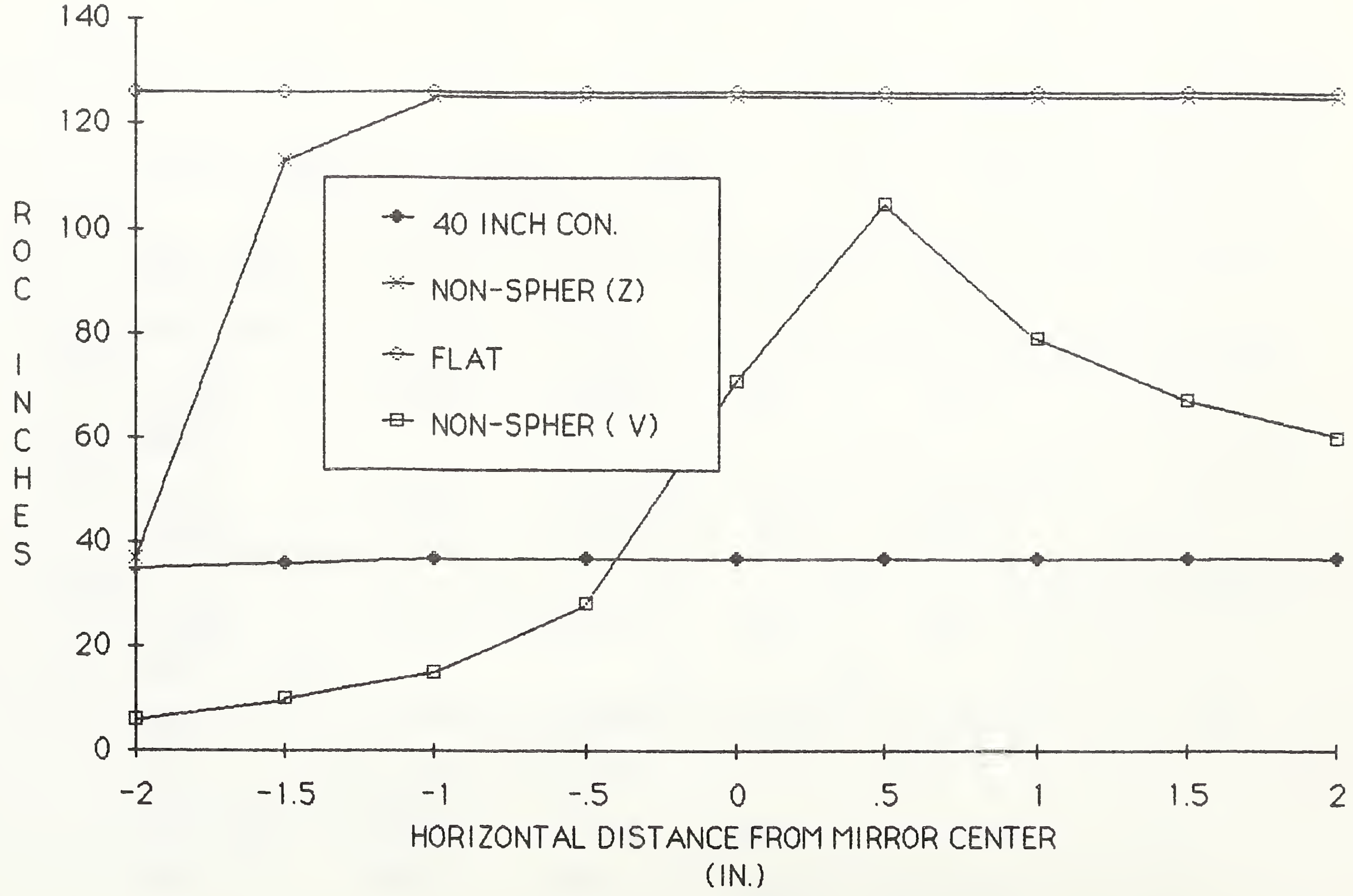


FIGURE 5 .1 COMPARISON OF AVERAGE HORIZONTAL SURFACE MIRROR RADII

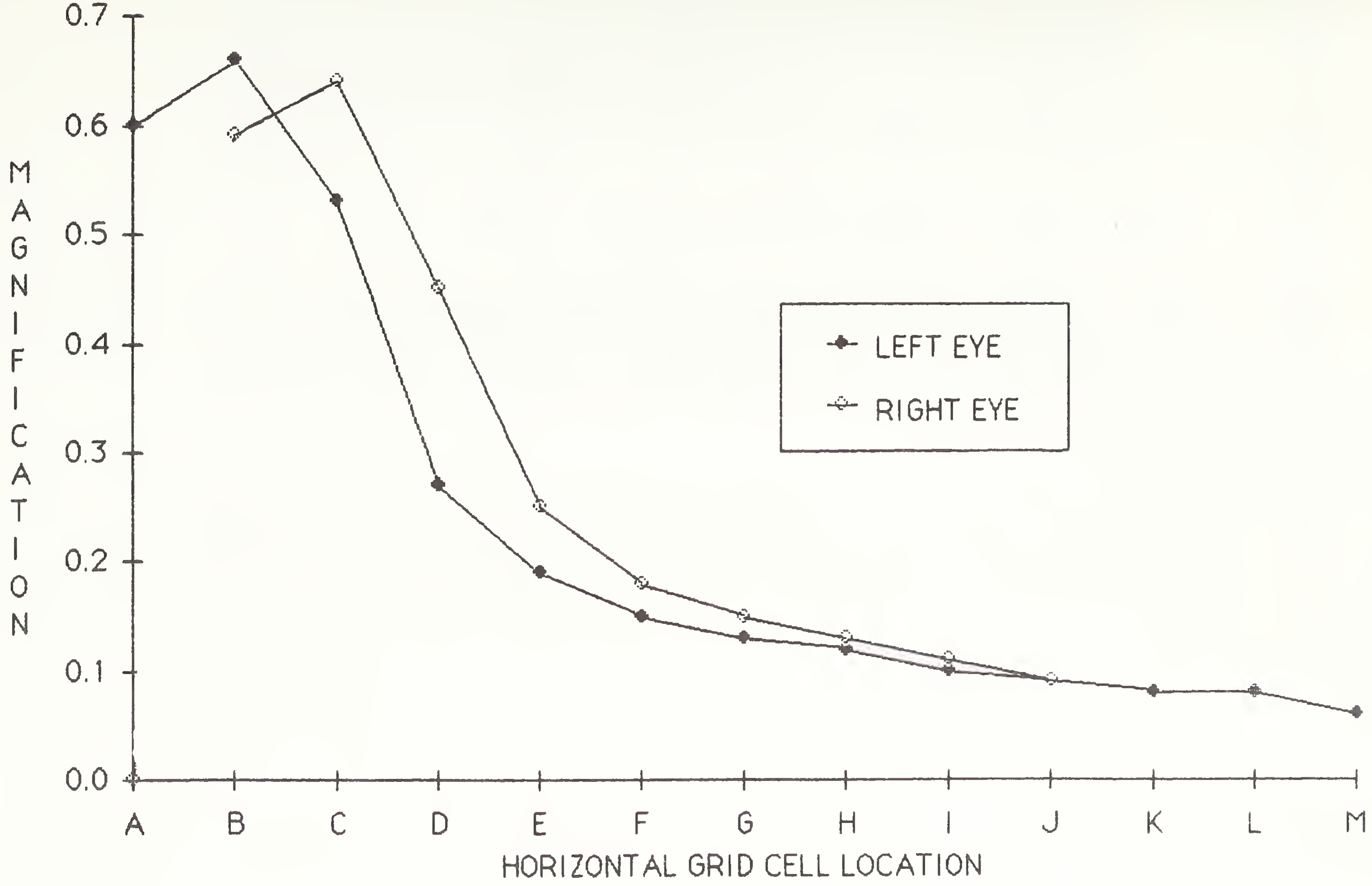


FIGURE 5.2 LEFT AND RIGHT EYE HORIZONTAL MAGNIFICATION FOR ALL GRID CELLS

APPENDIX A. RESULTS OF CHARACTERISTICS MEASUREMENTS

Characteristics measurements are presented in subsequent pages for the following mirrors;

A-1. 4.0 x 6.5 inch flat mirror

  a. left door mount
  b. right door mount

A-2. 4.0 x 6.5 inch 40 inch ROC spherical convex mirror

  a. left door mount
  b. right door mount

A-3. 4.0 x 6.5 inch non-spherical curved (V) mirror

  a. left door mount
  b. right door mount

A-4. 3.5 x 6.5 inch non-spherical curved (Z) mirror

  a. left door mount
  b. right door mount

A-5. 4.4 x 6.6 inch 20 inch ROC convex mirror

  a. right door mount

A-6. 4.1 x 3.7 inch plane / 2.0 x 3.7 inch 10 inch ROC spherical convex (K) mirror

  a. right door mount

A-1 DEVICE; 4.0 X 6.5 INCH FLAT MIRROR

A-1.1 LOCATION; LEFT DOOR MOUNT

A. GRID PHOTOS

1. LEFT EYE
2. RIGHT EYE

B. FIELD OF VIEW

1. LEFT EYE/RIGHT EYE
    a. horizontal
    b. vertical

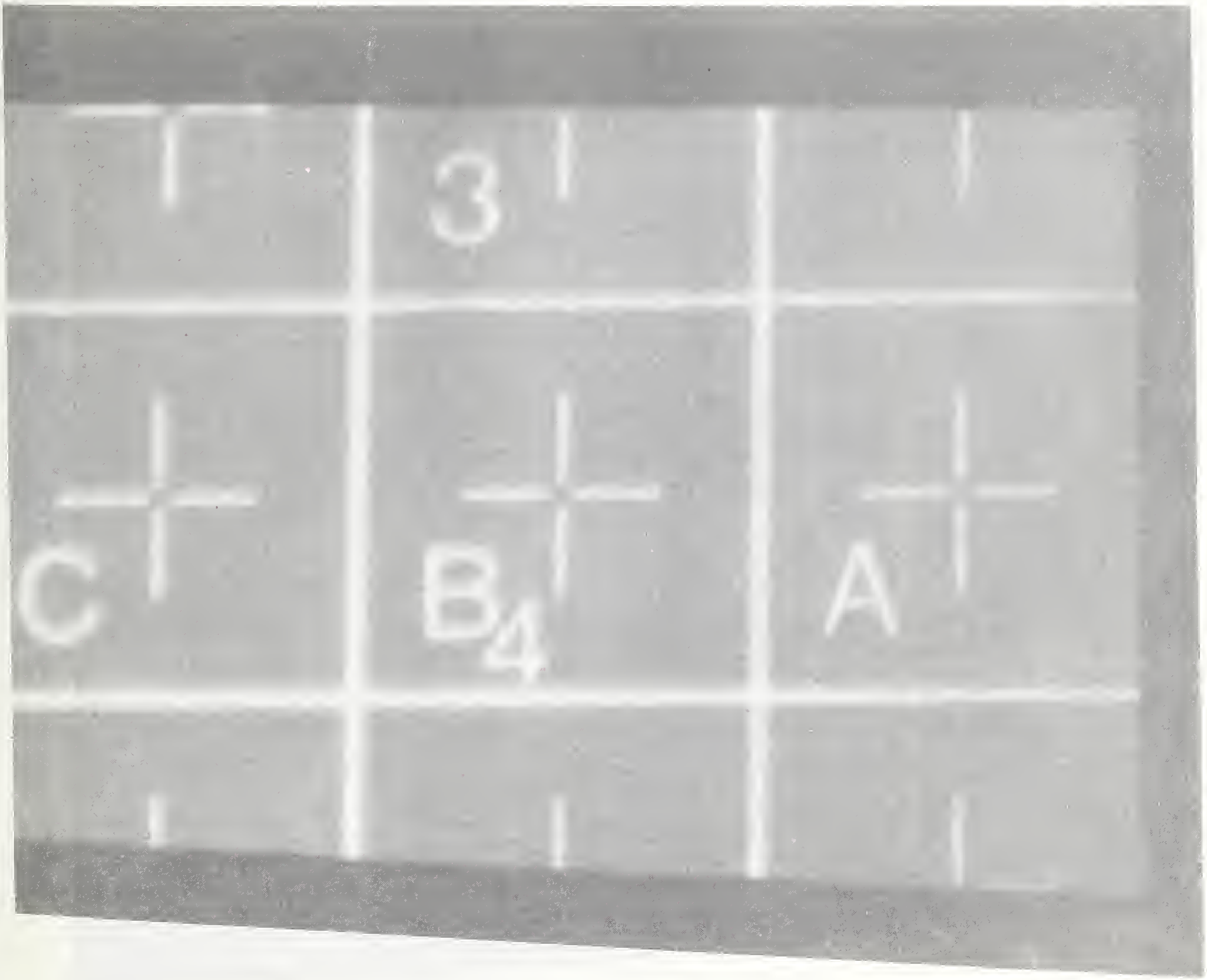
C. MAGNIFICATION
(none)

D. RADIUS OF CURVATURE
(none)

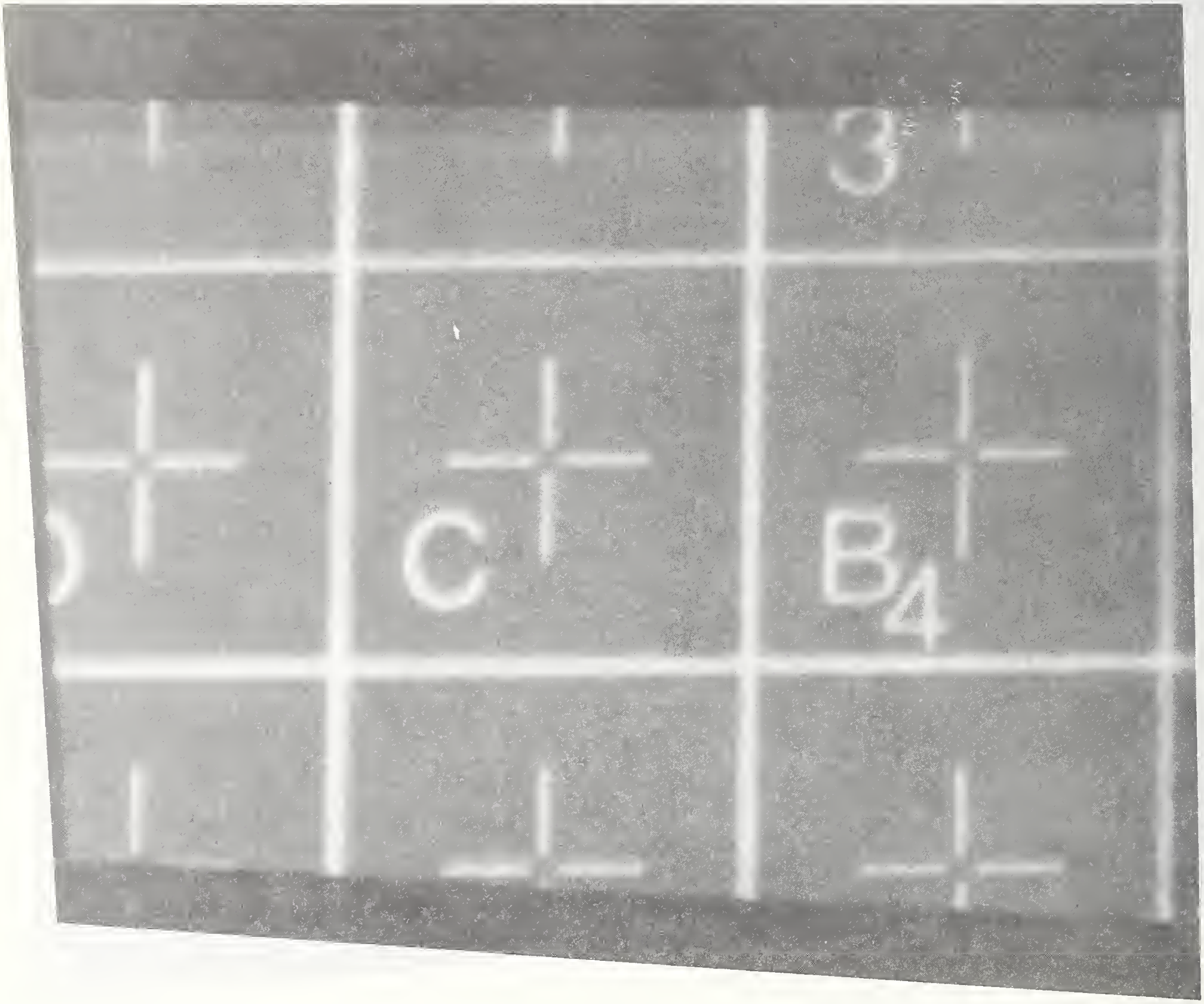
E. ACCOMMODATION

F. REFLECTANCE

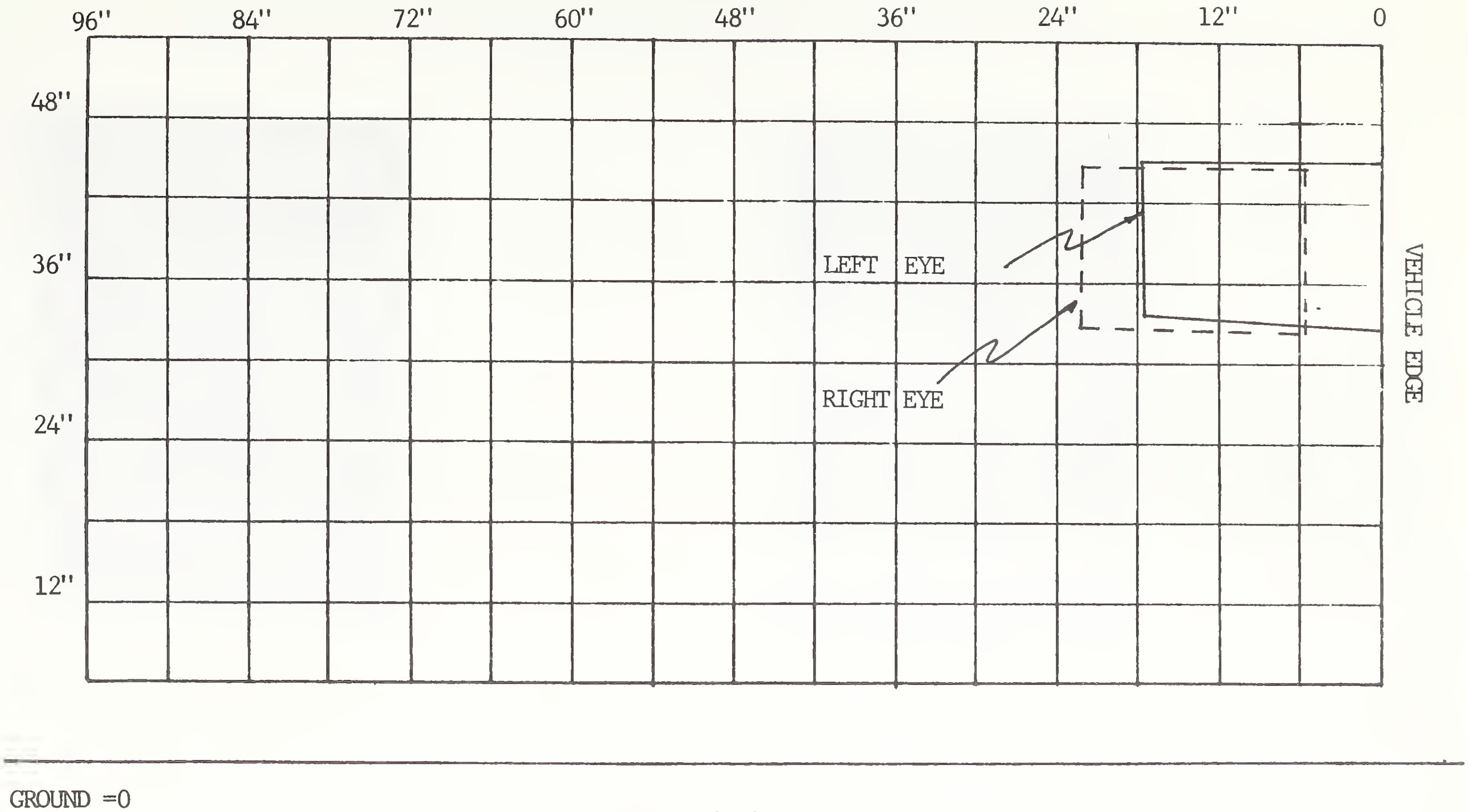
GRID PHOTO, PLANE MIRROR, LEFT DOOR MOUNT, LEFT EYE



GRID PHOTO, PLANE MIRROR, LEFT DOOR MOUNT, RIGHT EYE



PLANE MIRROR FOV, LEFT DOOR MOUNT
(LEFT AND RIGHT EYE)



SCALE: 1''=1'

A-1.2 LOCATION; RIGHT DOOR MOUNT

A. GRID PHOTOS

1. RIGHT EYE
2. LEFT EYE

B. FIELD OF VIEW

1. LEFT EYE/RIGHT EYE
   a. horizontal
   b. vertical

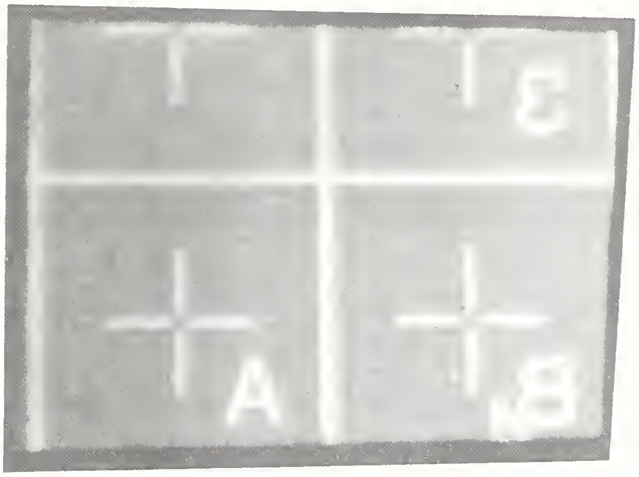
C. MAGNIFICATION
(none)

D. RADIUS OF CURVATURE
(none)

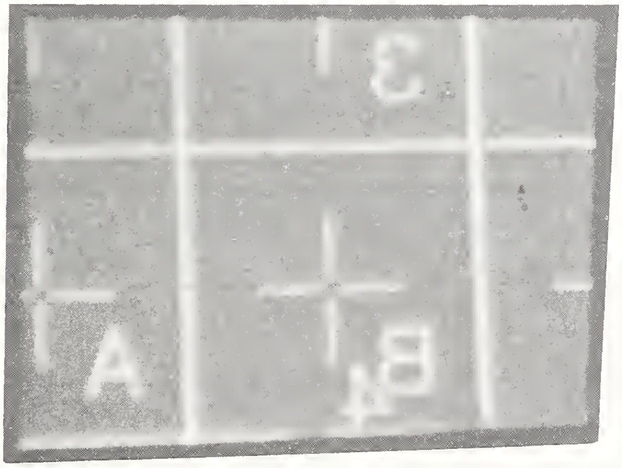
E. ACCOMMODATION

F. REFLECTANCE
(see left door mount data)

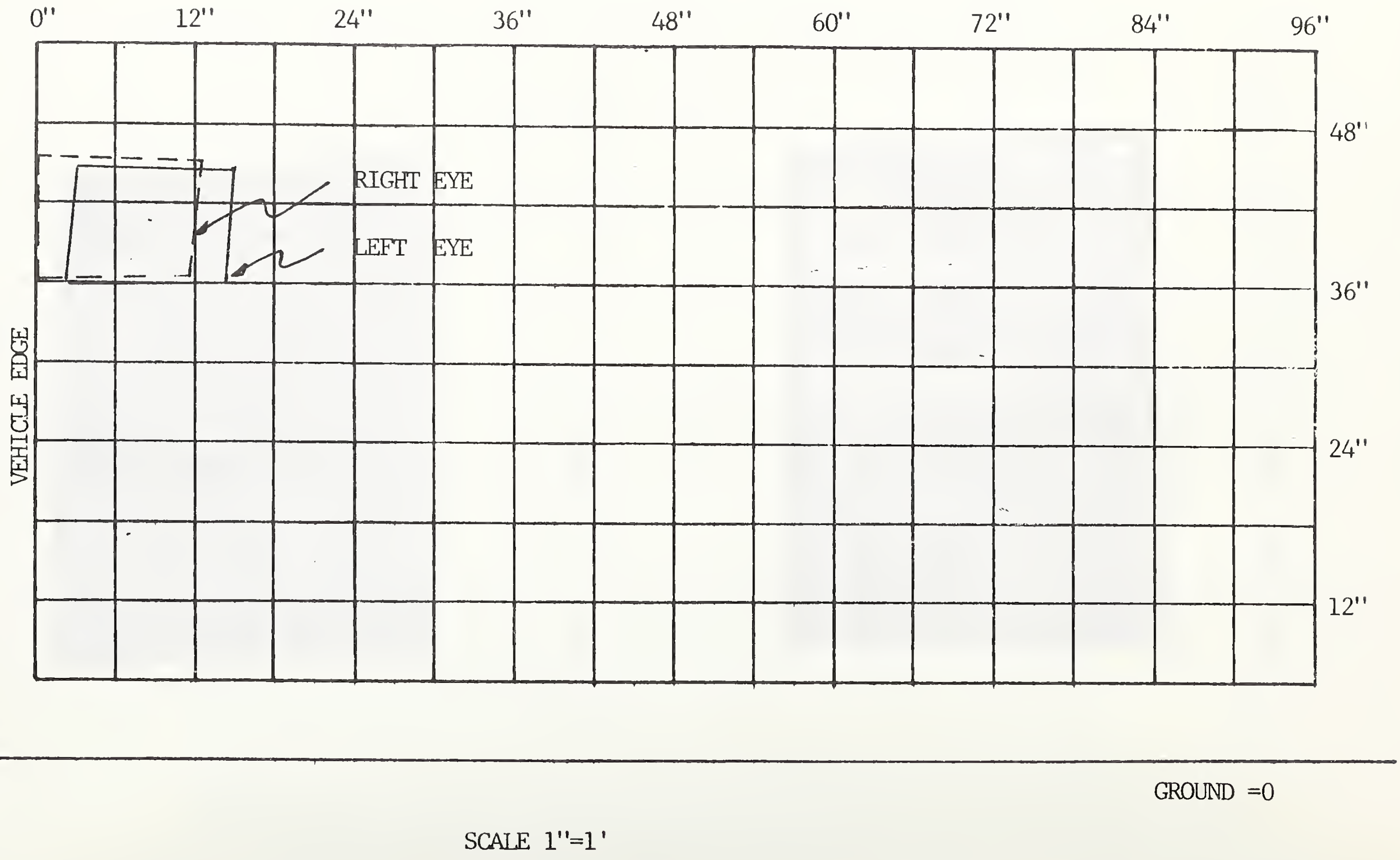
GRID PHOTO, PLANE MIRROR, RIGHT DOOR MOUNT, RIGHT EYE



GRID PHOTO, PLANE MIRROR, RIGHT DOOR MOUNT, LEFT EYE



PLANE MIRROR FOV, RIGHT DOOR MOUNT
(RIGHT AND LEFT EYE)



A.2 DEVICE; 4.0 X 6.5 INCH, 40 INCH ROC SPHERICAL MIRROR

A-2.1 LOCATION; LEFT DOOR MOUNT

A. GRID PHOTOS

1. LEFT EYE
2. RIGHT EYE

B. FIELD OF VIEW

1. LEFT EYE/RIGHT EYE
    a. horizontal
    b. vertical

C. MAGNIFICATION

1. HORIZONTAL
    a. left eye
    b. right eye

2. VERTICAL
    a. left eye
    b. right eye

D. RADIUS OF CURVATURE

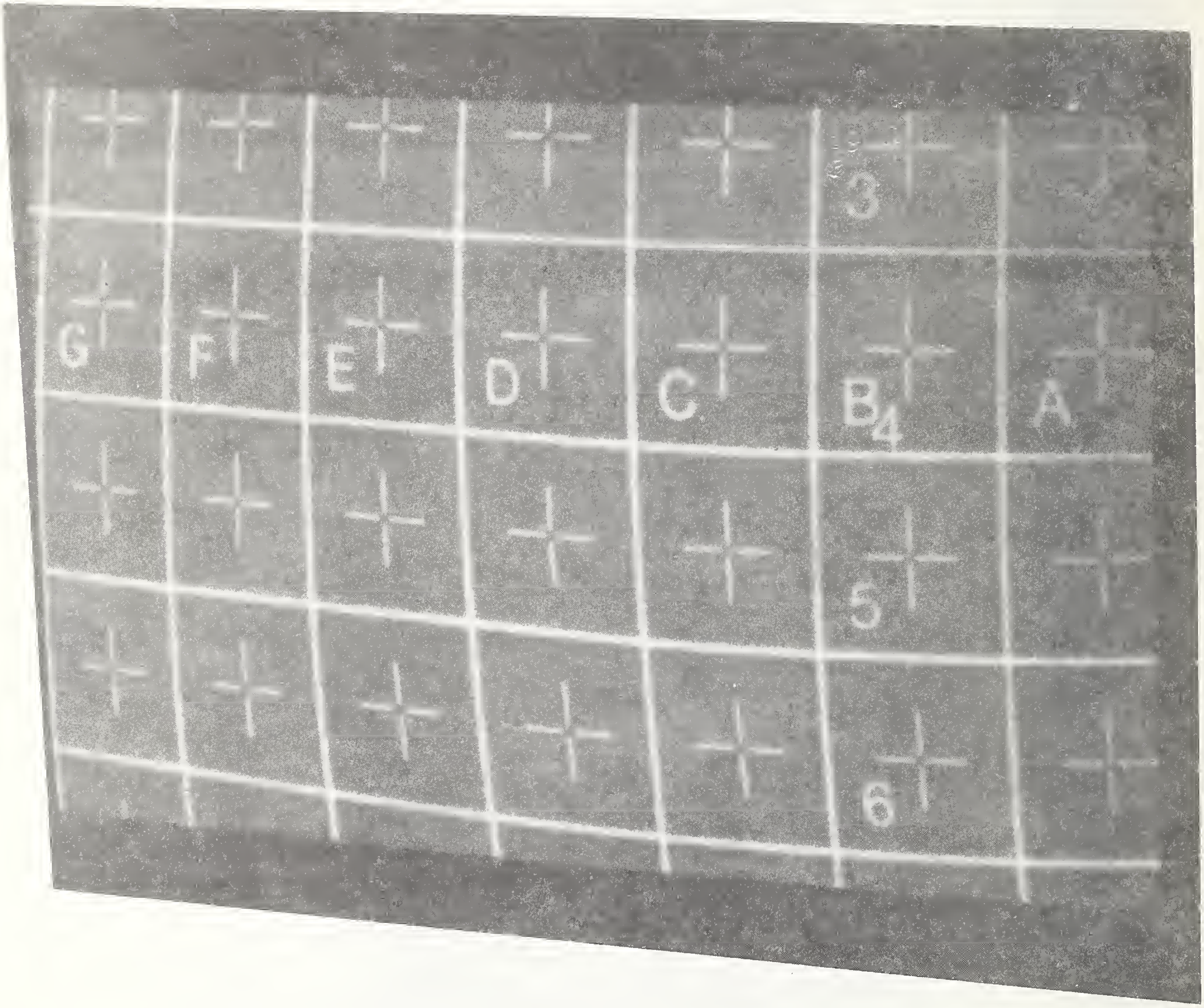
1. HORIZONTAL

2. VERTICAL

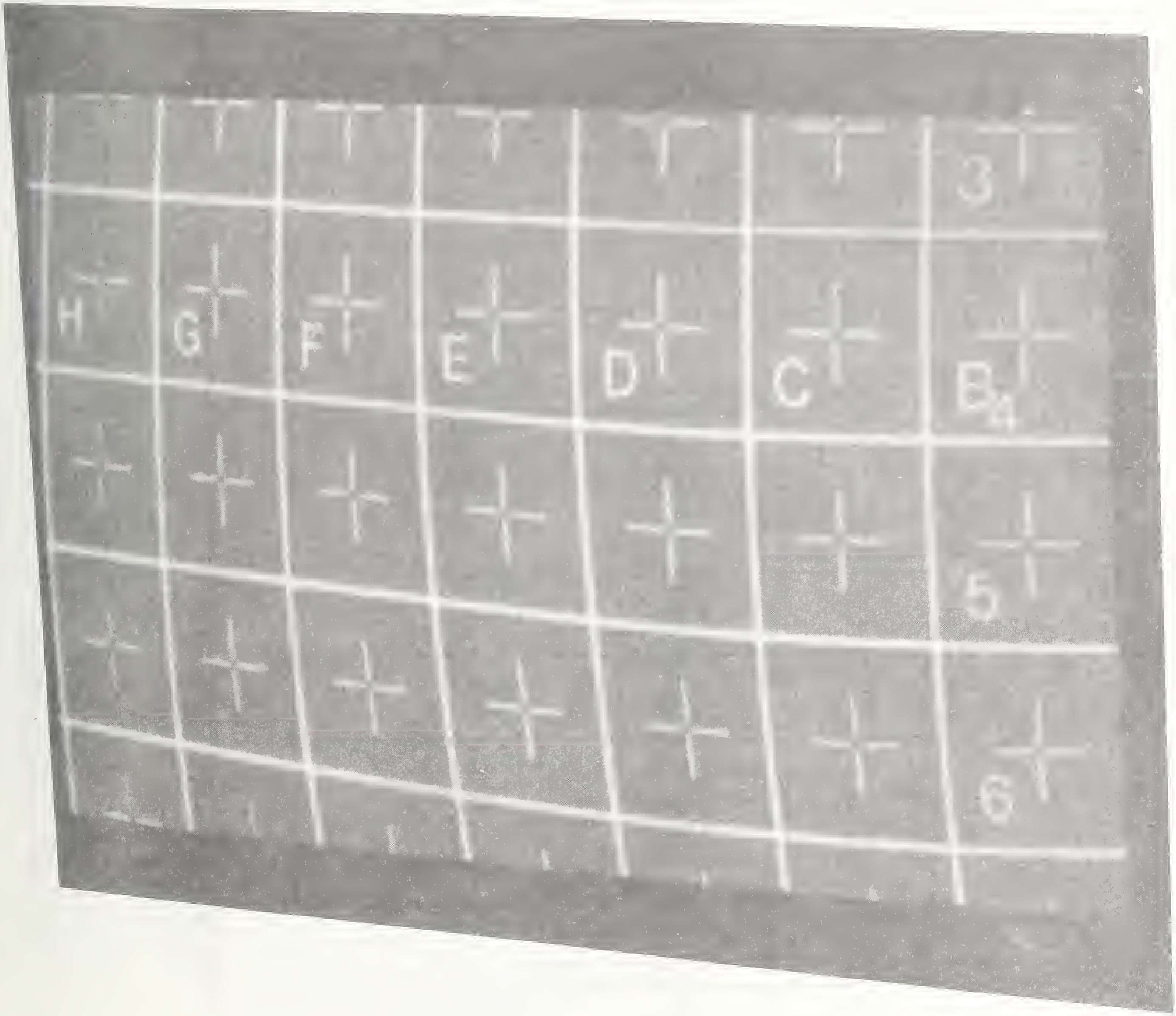
E. ACCOMMODATIONS DISTANCE

F. REFLECTANCE

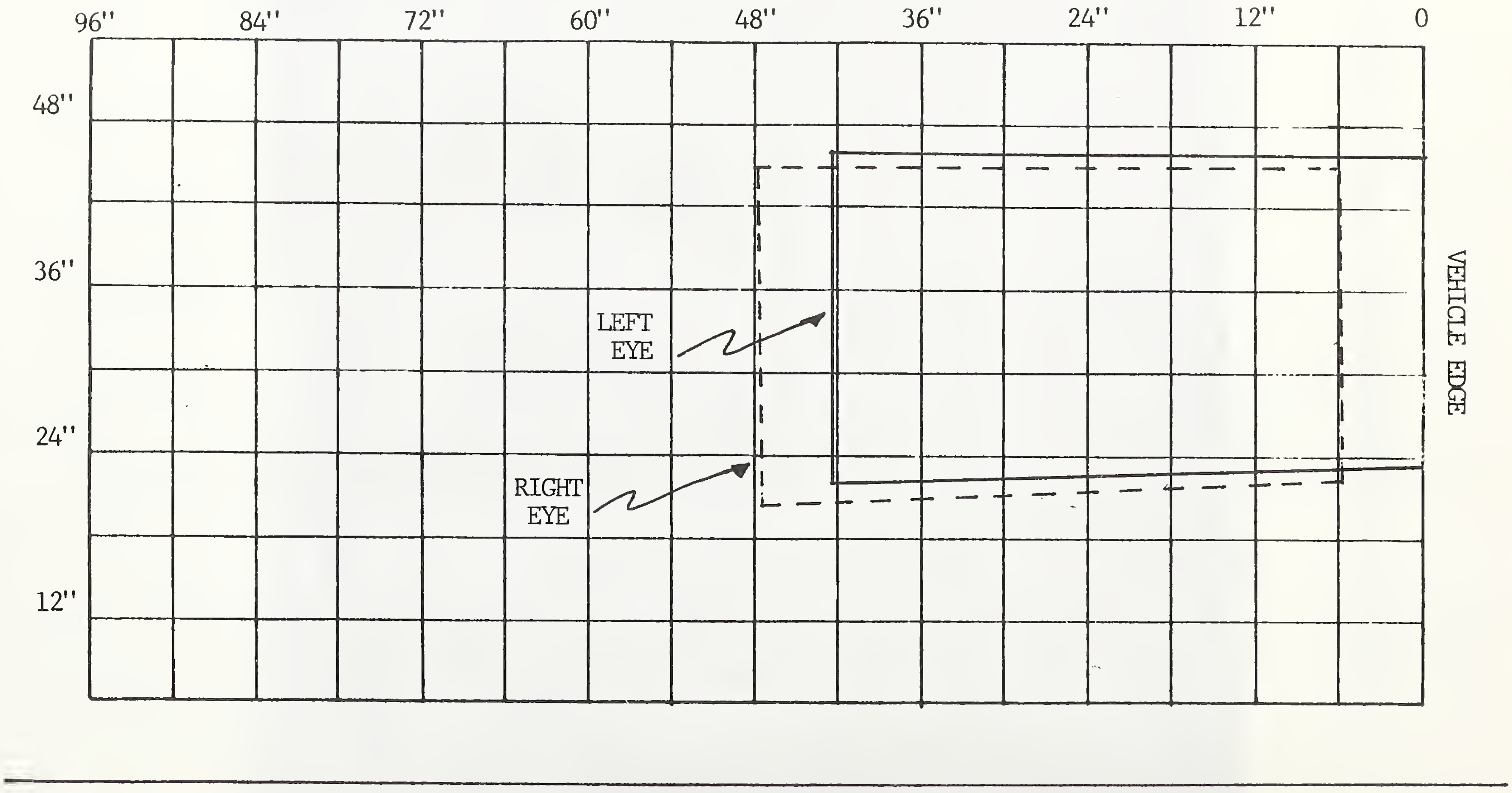
GRID PHOTO, 40" ROC MIRROR, LEFT DOOR MOUNT, LEFT EYE



GRID PHOTO, 40" ROC MIRROR, LEFT DOOR MOUNT, RIGHT EYE



40" ROC MIRROR FOV, LEFT DOOR MOUNT
(LEFT AND RIGHT EYE)



GROUND =0

SCALE: 1"=1'

MAGNIFICATION RECORDING FORM

DEVICE DESCRIPTION CONVEX 40" ROC

DEVICE DIMENSIONS 6.5X4.0 IN.

EYE REFERENCE LEFT

MAGN. MEASURE HORIZONTAL

DATE MEASURED

MEASURED BY

NOTES HORIZONTAL MAGNIFICATION FOR LEFT EYE

LEFT DOOR MOUNT

HORIZONTAL GRID CELL

VERTICAL GRID CELL	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
1																
2											↔			FOV		
3										.38	.39	.42	.45	.46	.47	—
4										.38	.39	.42	.46	.46	.47	—
5										.39	.40	.44	.46	.45	.47	—
6										.39	.41	.45	.46	.44	.46	—
7										—	—	—	—	—	—	—
8								$\bar{X}$		.39	.40	.44	.46	.45	.47	—

MAGNIFICATION RECORDING FORM

DEVICE DESCRIPTION CONVEX 40" ROC

DEVICE DIMENSIONS 6.5 X 4.0 IN.

EYE REFERENCE RIGHT

MAGN. MEASURE HORIZONTAL

DATE MEASURED

MEASURED BY

NOTES HORIZONTAL MAGNIFICATION FOR RIGHT EYE

LEFT DOOR MOUNT

HORIZONTAL GRID CELL

VERTICAL GRID CELL	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
1																
2														FOV		
3									.35	.37	.40	.42	.46	.45	.48	
4									.35	.38	.40	.42	.45	.43	.48	
5									.37	.38	.41	.44	.45	.45	.48	
6									.37	.38	.42	.44	.42	.45	.48	
7																
8							X		.36	.38	.41	.43	.45	.45	.48	—

MAGNIFICATION RECORDING FORM

DEVICE DESCRIPTION Convex 40" ROC

DEVICE DIMENSIONS 6.5 x 4.0 in.

EYE REFERENCE Left

MAGN. MEASURE Vertical

DATE MEASURED

MEASURED BY

NOTES Vertical magnification for left eye

Left door mount

HORIZONTAL GRID CELL

VERTICAL GRID CELL

	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
1																
2																
3																
4								↕		.55	.54	.53	.53	.52	.51	.51
5										.54	.53	.52	.51	.49	.49	.51
6										.54	.53	.53	.52	.49	.51	.51
7																
8								$\bar{X}$		.54	.53	.53	.52	.50	.50	.51

FOV

MAGNIFICATION RECORDING FORM

DEVICE DESCRIPTION Convex 40" ROC

DEVICE DIMENSIONS 6.5 x 4.0 in.

EYE REFERENCE Right

MAGN. MEASURE Vertical

DATE MEASURED

MEASURED BY

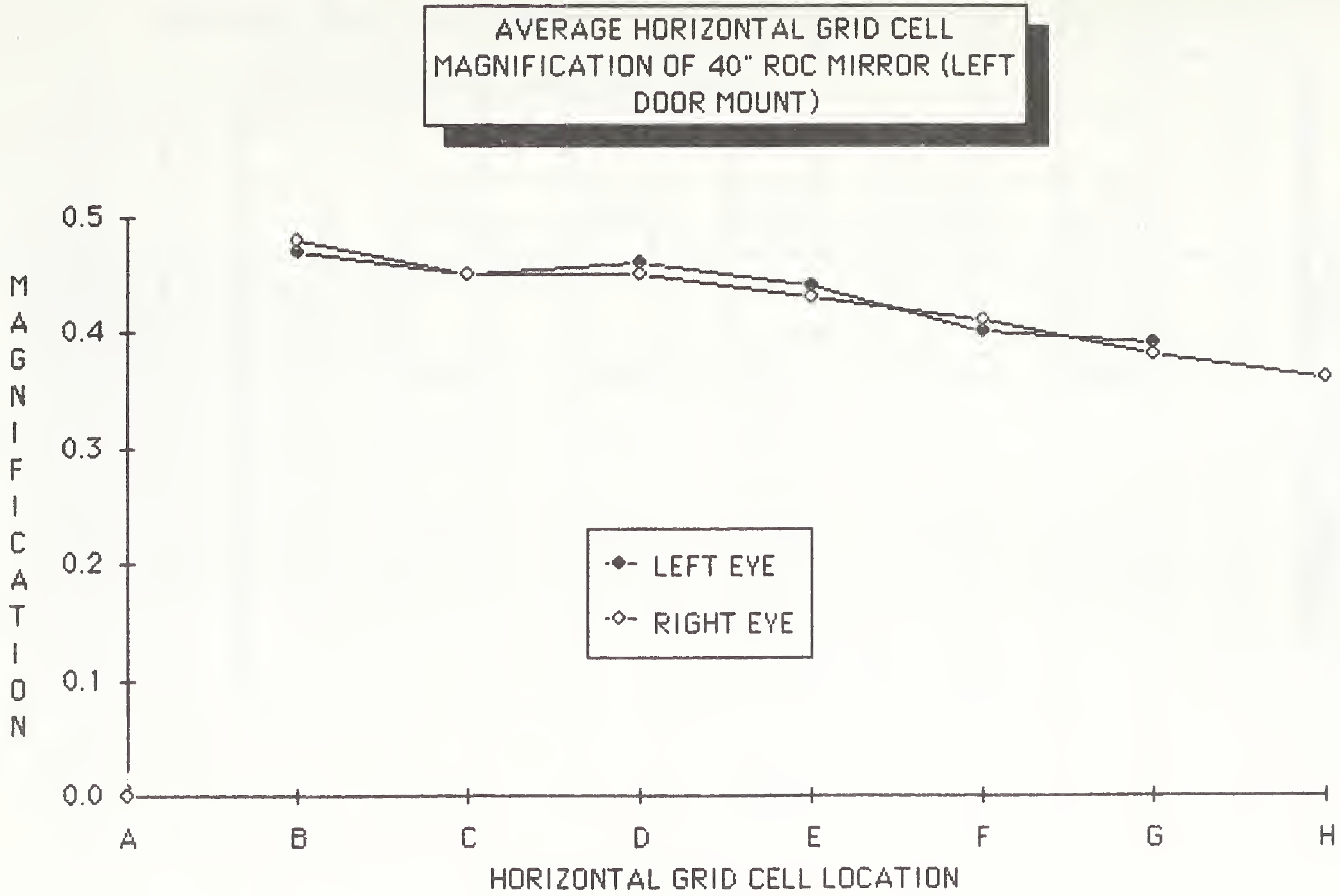
NOTES Vertical Magnification for Right Eye

Left Door Mount

HORIZONTAL GRID CELL

FOV

VERTICAL GRID CELL	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
1																
2																
3																
4									.58	.57	.55	.55	.54	.52	.51	
5									.58	.57	.53	.53	.52	.51	.51	
6									.55	.54	.54	.54	.52	.51	.51	
7																
8							$\bar{X}$		.57	.56	.54	.54	.53	.51	.51	


AVERAGE HORIZONTAL GRID CELL MAGNIFICATION OF 40" ROC MIRROR (LEFT DOOR MOUNT)
MAGNIFICATION
0.5
0.4
0.3
0.2
0.1
0.0
A
B
C
D
E
F
G
H
HORIZONTAL GRID CELL LOCATION
-◆- LEFT EYE
-◇- RIGHT EYE

RADIUS OF CURVATURE MEASUREMENT FORM

DEVICE Convex 40 inch MEASURED BY __________

MEASUREMENT Horizontal ROC (in.) DATE __________

HORIZONTAL DISTANCE FROM CENTER (IN.)

VERTICAL DISTANCE FROM CENTER (IN.)

	-4.0	-3.5	-3.0	-2.5	-2.0	-1.5	-1.0	-.5	0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
2.5																	
2.0																	$\overline{X}_H$
1.5																	
1.0					37		36		38		39		36				37
.5																	
0					36		36		37		37		34				36
-.5																	
-1.0					37		38		39		36		34				37
-1.5																	
-2.0																	
-2.5		$\overline{X}_H$			37		37		37		37		35				

INSIDE MIRROR EDGE

RADIUS OF CURVATURE MEASUREMENT FORM

DEVICE Convex 40 inch

MEASURED BY

MEASUREMENT Vertical ROC (in.)

DATE

HORIZONTAL DISTANCE FROM CENTER (IN.)

VERTICAL DISTANCE FROM CENTER (IN.)

	-4.0	-3.5	-3.0	-2.5	-2.0	-1.5	-1.0	-.5	0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
2.5																	
2.0																	$\overline{X_V}$
1.5																	
1.0					40		38		38		38		37			INSIDE MIRROR EDGE	38
.5																	
0					39		38		37		37		37				38
-.5																	
-1.0					39		39		39		38		37				38
-1.5																	
-2.0																	
-2.5		$\overline{X_V}$			39		38		37		38		37				

A-2.2 LOCATION; RIGHT DOOR MOUNT

A. GRID PHOTOS

1. LEFT EYE
2. RIGHT EYE

B. FIELD OF VIEW

1. LEFT EYE/RIGHT EYE
    a. horizontal
    b. vertical

C. MAGNIFICATION

1. HORIZONTAL
    a. left eye
    b. right eye

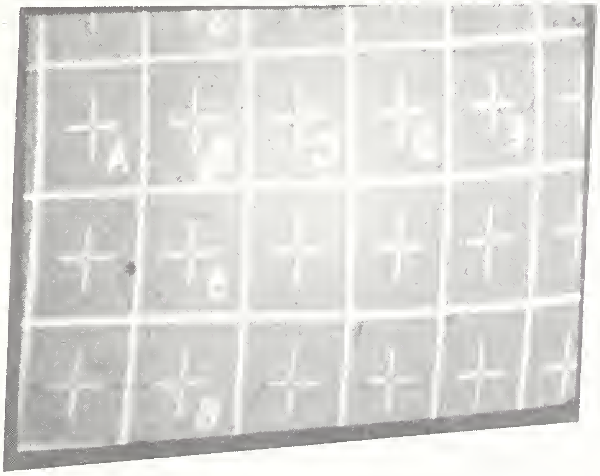
2. VERTICAL
    a. left eye
    b. right eye

D. RADIUS OF CURVATURE
(See left door mount data)

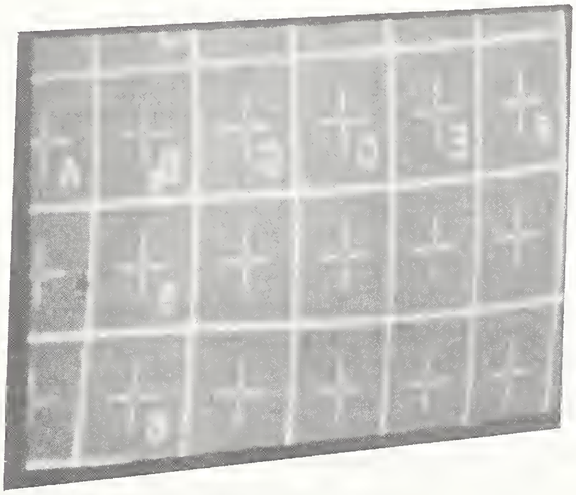
E. ACCOMMODATIONS DISTANCE

F. REFLECTANCE
(See left door mount data)

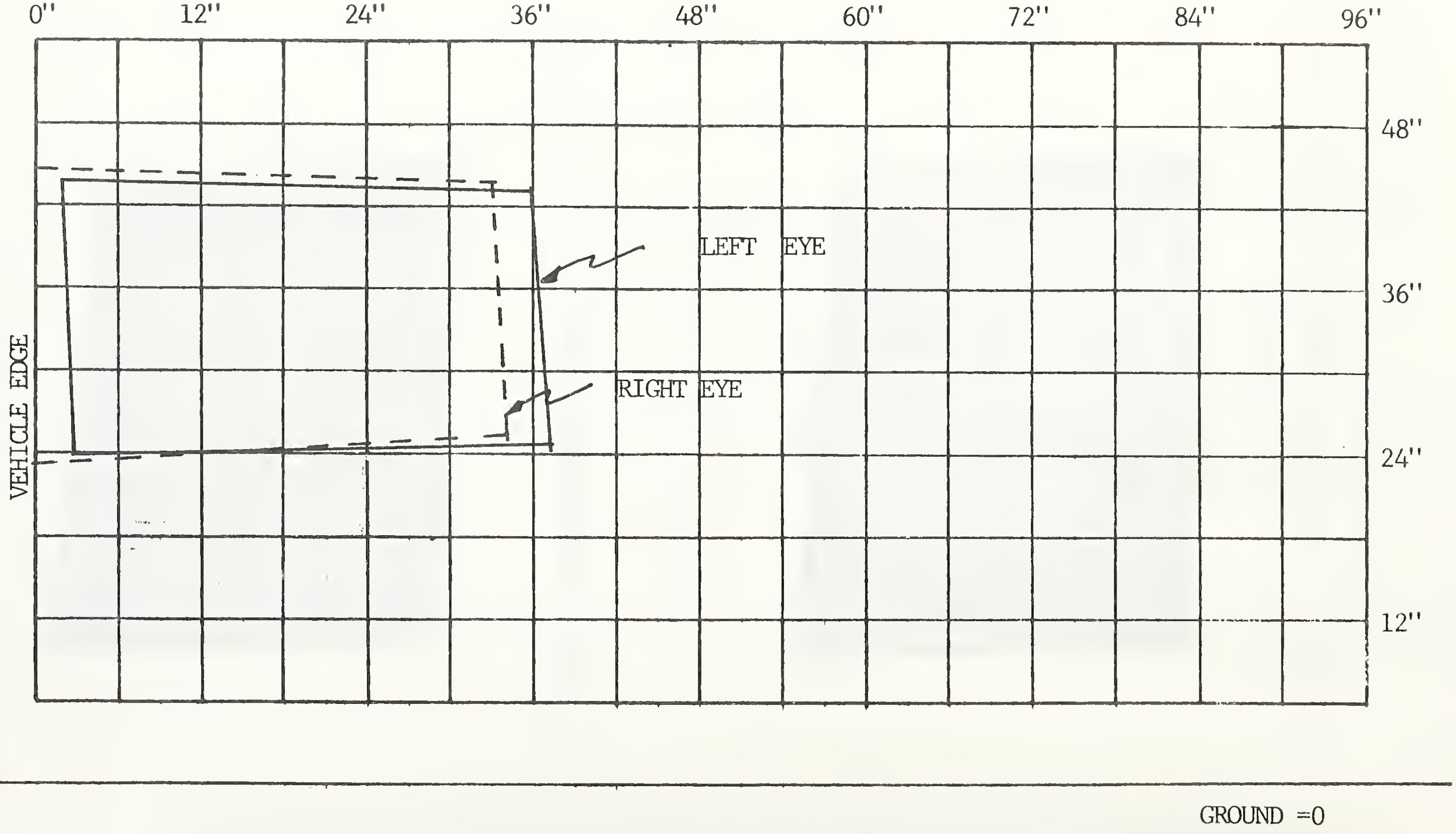
GRID PHOTO, 40 " ROC MIRROR, RIGHT DOOR MOUNT, RIGHT EYE



GRID PHOTO, 40 " ROC MIRROR, RIGHT DOOR MOUNT, LEFT EYE



40" ROC SPHERICAL MIRROR FOV,
RIGHT DOOR MOUNT (LEFT AND RIGHT EYE)



SCALE 1"=1'

MAGNIFICATION RECORDING FORM (M-1)

DEVICE DESCRIPTION CONVEX 40" ROC

DEVICE DIMENSIONS 6.5 X 4.0

EYE REFERENCE RIGHT

MAGN. MEASURE HORIZONTAL

DATE MEASURED

MEASURED BY

NOTES Photo CORRECT 1.778

HORIZONTAL GRID CELL

VERTICAL GRID CELL

	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
1																
2																
3																
4	.358	.362	.360	.349	.362											
5	.366	.375	.368	.341	326											
6	.322	.345	.364	.322	.319											
7																
8																

MAGNIFICATION RECORDING FORM (M-1)

DEVICE DESCRIPTION Convex 40" ROC

DEVICE DIMENSIONS 6.5x4.0

EYE REFERENCE LEFT

MAGN. MEASURE HORIZ

DATE MEASURED

MEASURED BY

NOTES

Photo Corr 1.786

HORIZONTAL GRID CELL

VERTICAL GRID CELL

	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
1																
2																
3																
4		.355	.349	.354	.316	.322										
5		.359	.359	.345	.312	.315										
6		.372	.366	.330	.305	.304										
7																
8																

MAGNIFICATION RECORDING FORM (M-1)

DEVICE DESCRIPTION CONVEX 40" RC

DEVICE DIMENSIONS 6.5 x 4.0

EYE REFERENCE RIGHT

MAGN. MEASURE VERTICLE

DATE MEASURED

MEASURED BY

NOTES

Photo Corr 1.778

HORIZONTAL GRID CELL

VERTICAL GRID CELL

	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
1																
2																
3																
4	.454	.461	.467	.481	.484	.493										
5	.446	.459	.461	.474	.490	.493										
6	.446															
7																
8																

MAGNIFICATION RECORDING FORM (M-1)

DEVICE DESCRIPTION Convex 40"Roc

DEVICE DIMENSIONS 6.5X4.0

EYE REFERENCE LEFT

MAGN. MEASURE VERTICLE

DATE MEASURED

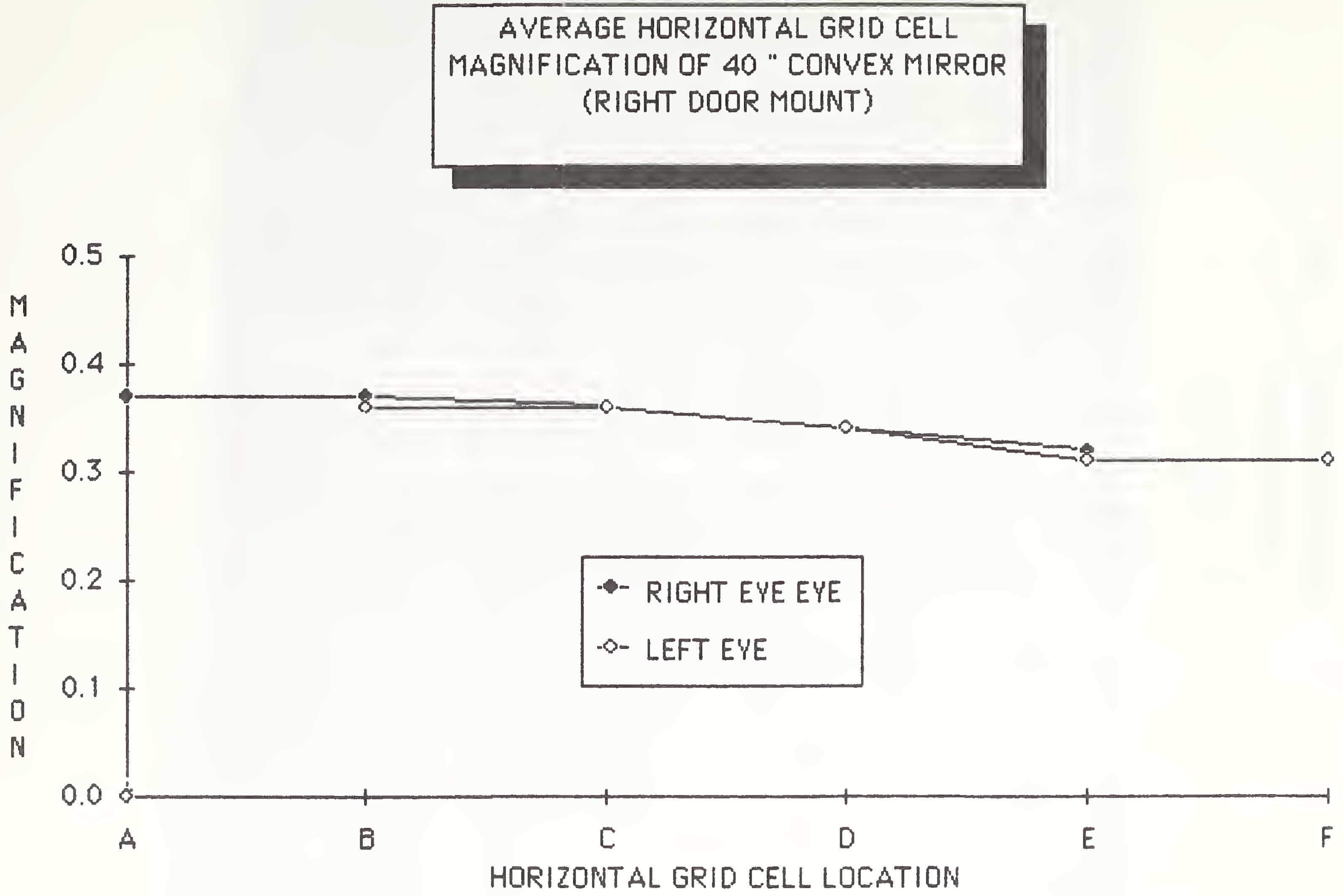
MEASURED BY

NOTES

Photo Covr 1.786

HORIZONTAL GRID CELL

VERTICAL GRID CELL	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
1																
2																
3																
4	.456	.463	.470	.483	.490	.496										
5	.452	.461	.466	.477	.486	.502										
6		.461														
7																
8																


AVERAGE HORIZONTAL GRID CELL
MAGNIFICATION OF 40 " CONVEX MIRROR
(RIGHT DOOR MOUNT)
MAGNIFICATION
0.5
0.4
0.3
0.2
0.1
0.0
A
B
C
D
E
F
HORIZONTAL GRID CELL LOCATION
RIGHT EYE EYE
LEFT EYE

A-3 DEVICE; 4.0 X 6.5 NON-SPHERICAL/CURVED (V) MIRROR

A-3.1 LOCATION; LEFT DOOR MOUNT

A. GRID PHOTOS

1. LEFT EYE
2. RIGHT EYE

B. FIELD OF VIEW

1. LEFT EYE/RIGHT EYE
    a. horizontal
    b. vertical

C. MAGNIFICATION

1. HORIZONTAL
    a. left eye
    b. right eye

2. VERTICAL
    a. left eye
    b. right eye

D. RADIUS OF CURVATURE

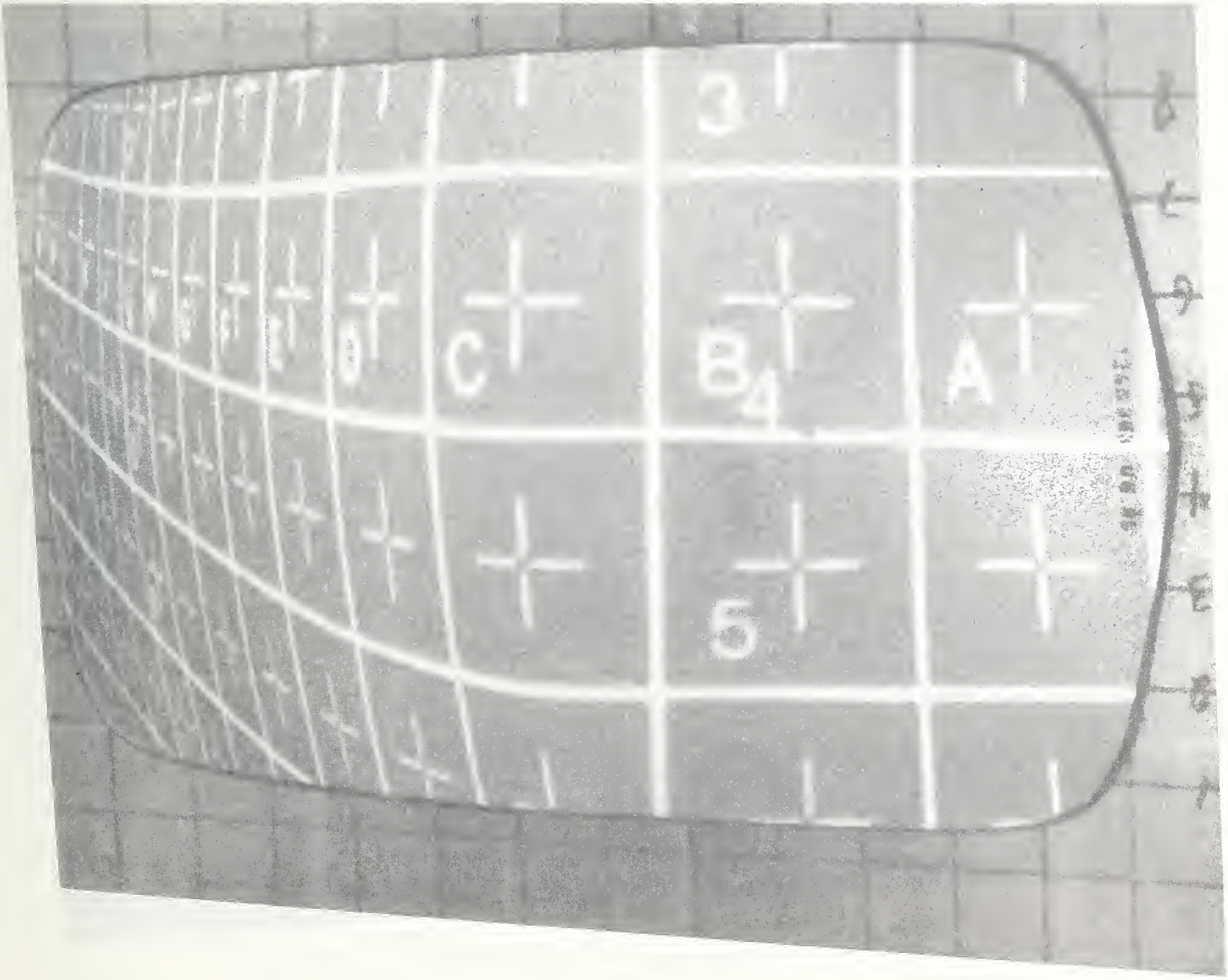
1. HORIZONTAL

2. VERTICAL

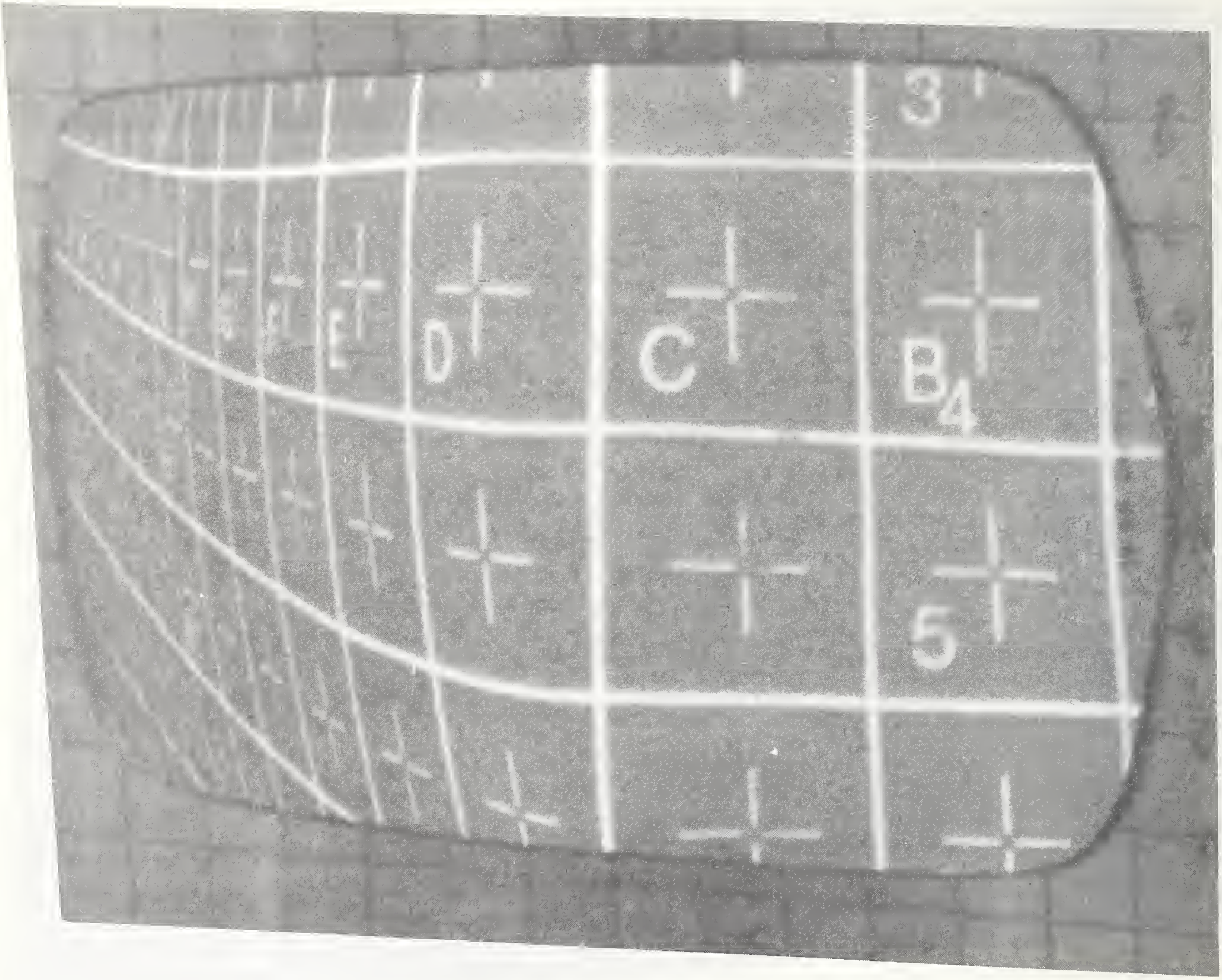
E. ACCOMMODATIONS DISTANCE

F. REFLECTANCE

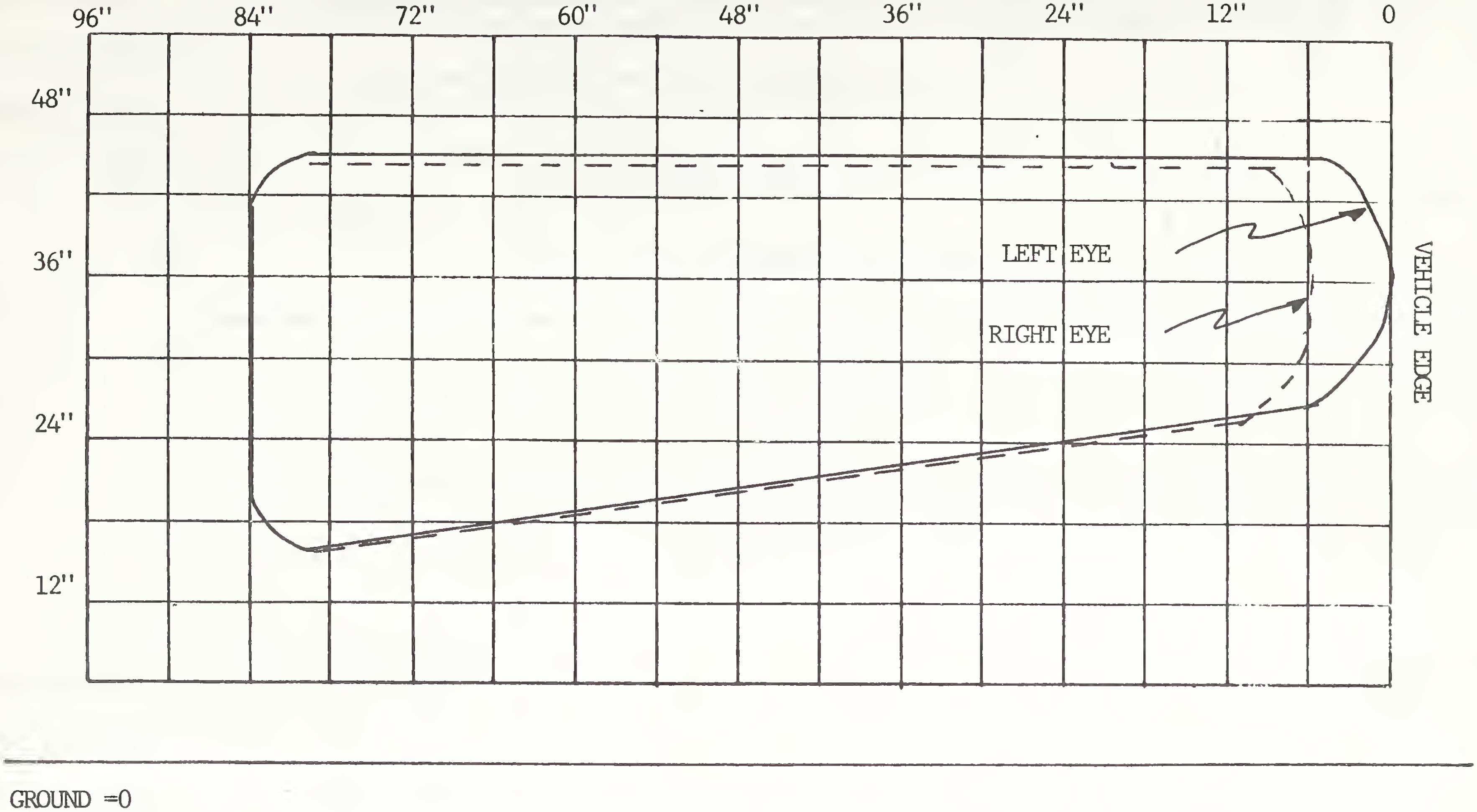
GRID PHOTO, NON-SPHERICAL/CURVED MIRROR,
LEFT DOOR MOUNT, LEFT EYE



GRID PHOTO, NON-SPHERICAL/CURVED (V) MIRROR,
LEFT DOOR MOUNT, RIGHT EYE



NON-SPHERICAL/CURVED (V) MIRROR FOV,
LEFT DOOR MOUNT
(LEFT AND RIGHT EYE)



SCALE: 1''=1'

MAGNIFICATION RECORDING FORM

DEVICE DESCRIPTION NON-SPHERICAL /CURVED (V)
DEVICE DIMENSIONS 6.5X4.0 IN.
EYE REFERENCE LEFT
MAGN. MEASURE HORIZONTAL
DATE MEASURED
MEASURED BY

NOTES HORIZONTAL MAGNIFICATION
FOR LEFT EYE

LEFT DOOR MOUNT

HORIZONTAL GRID CELL

VERTICAL GRID CELL

	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
1																
2													FOV			
3				–	.07	.07	.08	.09	.11	.12	.15	.19	.26	.54	.64	—
4				-	.07	.07	.08	.09	.11	.12	.14	.19	.26	.57	.65	.60
5				.06	.08	.08	.08	.09	.11	.13	.15	.17	.27	.54	.66	.60
6				.06	.08	.09	.11	.11	.13	.14	.17	.21	.29	.45	.68	
7																
8	$\bar{X}$			.06	.08	.08	.09	.10	.12	.13	.15	.19	.27	.53	.66	.60

MAGNIFICATION RECORDING FORM

DEVICE DESCRIPTION Non-Spherical / Curved (V)

DEVICE DIMENSIONS 6.5 x 4.0 in.

EYE REFERENCE Right

MAGN. MEASURE Horizontal

DATE MEASURED

MEASURED BY

NOTES Horizontal Magnification for Right Eye

Left Door Mount

HORIZONTAL GRID CELL

VERTICAL GRID CELL

	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
1																
2								↔								
3			—	—	—	—	.08	.09	.11	.13	.17	.24	.46	.62	—	—
4							.08	.09	.11	.14	.17	.24	.49	.62	.58	—
5							.09	.11	.13	.15	.18	.24	.46	.66	.59	—
6							.12	.15	.17	.18	.19	.27	.40	.65	.60	—
7			—	—	—		—		—	—						
8	X						.09	.11	.13	.15	.18	.25	.45	.64	.59	—

Too Small to Measure

MAGNIFICATION RECORDING FORM

DEVICE DESCRIPTION Non-Spherical /Curved (V)

DEVICE DIMENSIONS 6.5 x 4.0 in.

EYE REFERENCE Left

MAGN. MEASURE Vertical

DATE MEASURED

MEASURED BY

NOTES Vertical Magnification
For Left Eye

Left Door Mount

HORIZONTAL GRID CELL

VERTICAL GRID CELL	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
1																
2														FOV		
3																
4				.51	.51	.51	.51	.52	.52	.55	.57	.60	.64	.65	.65	.68
5				.51	.51	.51	.52	.52	.52	.51	.55	.58	.62	.65	.64	.64
6				.48	.48	.48	.51	.49	.51	.51	.54					
7																
8	$\bar{X}$			.50	.50	.50	.51	.51	.52	.52	.55	.59	.63	.65	.65	.66

MAGNIFICATION RECORDING FORM

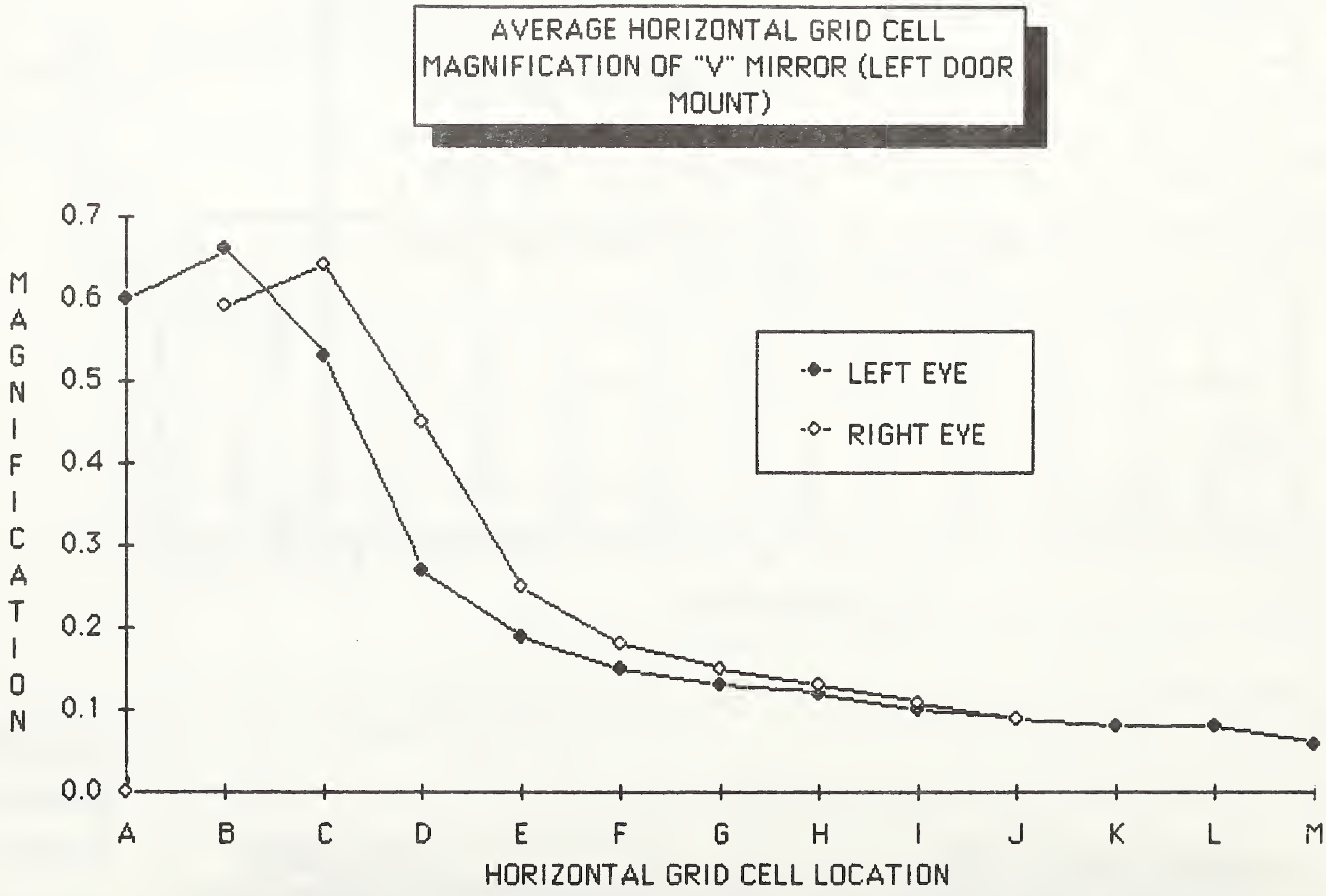
DEVICE DESCRIPTION Non-Spherical /Curved (V)
DEVICE DIMENSIONS 6.5 X 4.0 in.
EYE REFERENCE Right
MAGN. MEASURE Vertical
DATE MEASURED
MEASURED BY

NOTES Vertical magnification
for Right Eye

Left Door Mount

HORIZONTAL GRID CELL

VERTICAL GRID CELL	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
1																
2																
3																
4				.51	.52	.52	.54	.54	.55	.58	.61	.65	.65	.66	.67	
5				.49	.52	.52	.54	.54	.52	.55	.60	.62	.65	.65	.62	
6				.48	.48	.47	.49	.51	.52	.53	.55					
7																
8	X			.49	.51	.50	.52	.53	.53	.55	.59	.64	.65	.66	.65	—

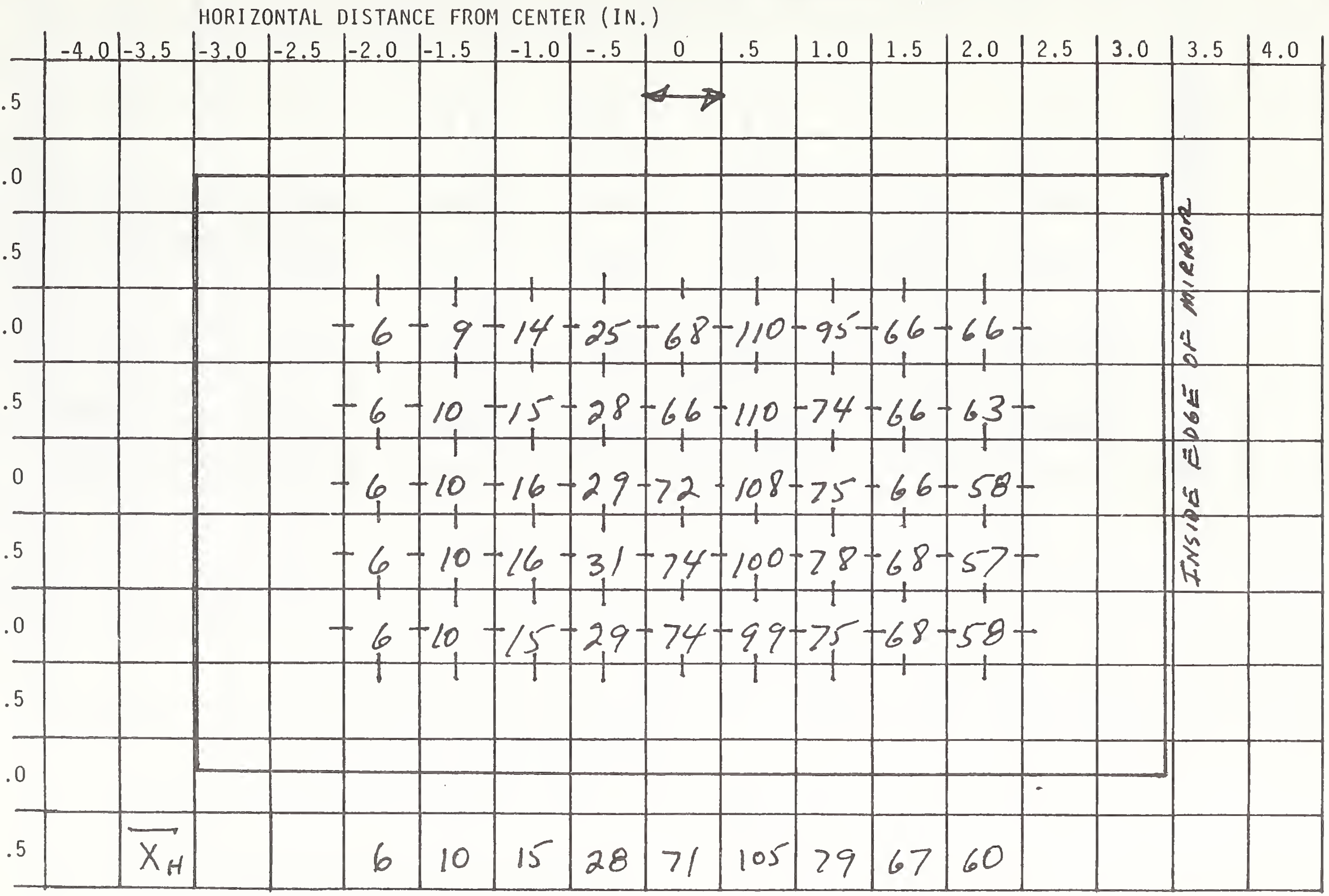

AVERAGE HORIZONTAL GRID CELL MAGNIFICATION OF "V" MIRROR (LEFT DOOR MOUNT)
-◆- LEFT EYE
-◇- RIGHT EYE
MAGNIFICATION
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
A
B
C
D
E
F
G
H
I
J
K
L
M
HORIZONTAL GRID CELL LOCATION

RADIUS OF CURVATURE MEASUREMENT FORM

NON-SPHERICAL/CURVED(V)

DEVICE ________ MEASURED BY ________

MEASUREMENT Horizontal ROC (in.) DATE ________



HORIZONTAL DISTANCE FROM CENTER (IN.)

VERTICAL DISTANCE FROM CENTER (IN.)

	-4.0	-3.5	-3.0	-2.5	-2.0	-1.5	-1.0	-.5	0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
2.5																	
2.0																	
1.5																	
1.0					6	9	14	25	68	110	95	66	66				
.5					6	10	15	28	66	110	74	66	63				
0					6	10	16	29	72	108	75	66	58				
-.5					6	10	16	31	74	100	78	68	57				
-1.0					6	10	15	29	74	99	75	68	58				
-1.5																	
-2.0																	
-2.5		$\overline{X}_H$			6	10	15	28	71	105	29	67	60				

RADIUS OF CURVATURE MEASUREMENT FORM

DEVICE Non-Spherical/Curved(V) MEASURED BY

MEASUREMENT Vertical ROC (in.) DATE

HORIZONTAL DISTANCE FROM CENTER (IN.)

VERTICAL DISTANCE FROM CENTER (IN.)

	-4.0	-3.5	-3.0	-2.5	-2.0	-1.5	-1.0	-.5	0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
2.5																	
2.0																	
1.5																	
1.0				X		39		63		72		70		68			
.5				27		43		66		74		68		63			
0				28		45		68		74		68		65			
-.5				28		44		70		70		69		72			
-1.0				X		44		68		68		75		80			
-1.5																	
-2.0																	
-2.5		$\overline{X_V}$		28		43		67		72		70		71			

INSIDE EDGE OF MIRROR

A-3.2 LOCATION; RIGHT DOOR MOUNT

A. GRID PHOTOS

1. LEFT EYE
2. RIGHT EYE

B. FIELD OF VIEW

1. LEFT EYE/RIGHT EYE
    a. horizontal
    b. vertical

C. MAGNIFICATION

1. HORIZONTAL
    a. right eye
    b. left eye

2. VERTICAL
    a. right eye
    b. left eye

D. RADIUS OF CURVATURE

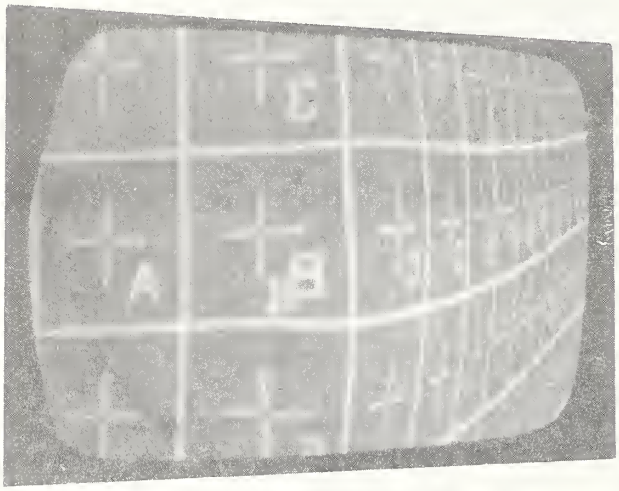
(See left door mount data)

E. ACCOMMODATIONS DISTANCE

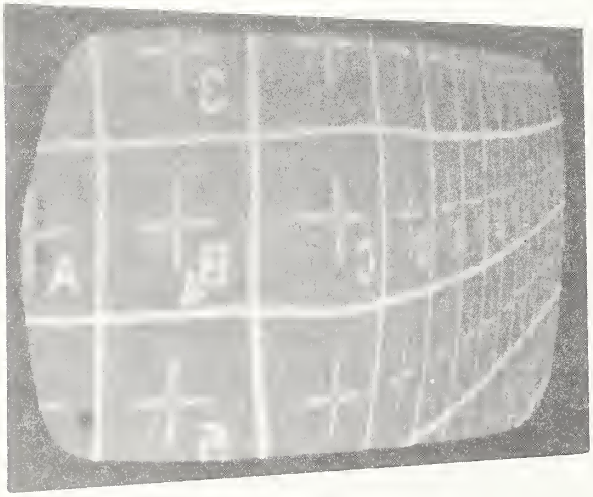
F. REFLECTANCE

(See left door mount data)

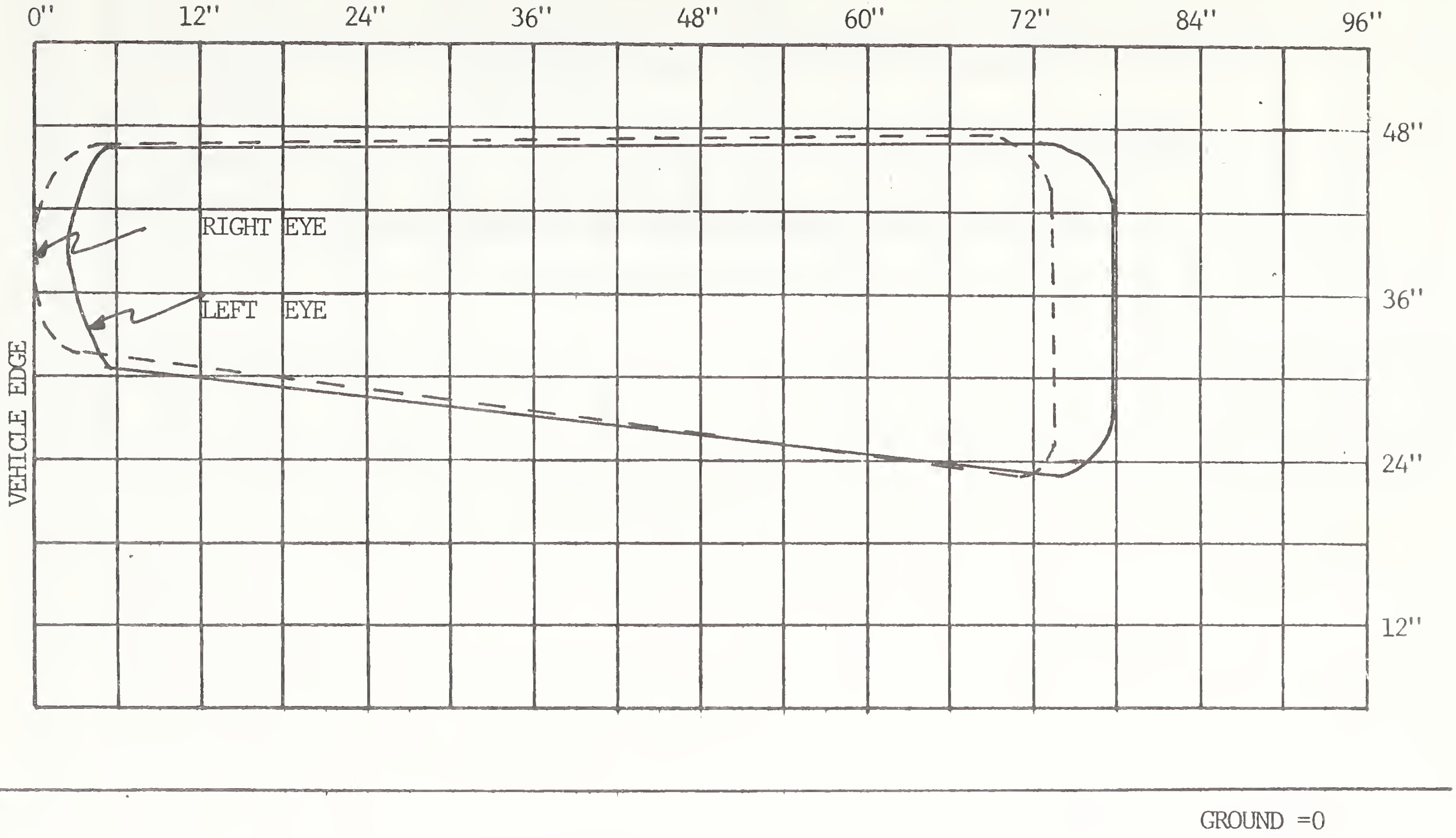
GRID PHOTO, NON-SPHERICAL/CURVED (V) MIRROR,
RIGHT DOOR MOUNT, RIGHT EYE



GRID PHOTO, NON-SPHERICAL/CURVED (V) MIRROR,
RIGHT DOOR MOUNT, LEFT EYE



NON-SPHERICAL/CURVED (V) MIRROR FOV, RIGHT DOOR MOUNT (RIGHT AND LEFT EYE)



SCALE 1''=1'

MAGNIFICATION RECORDING FORM (M-1)

DEVICE DESCRIPTION Non Spher (V)

DEVICE DIMENSIONS 6.5 x 4.0

EYE REFERENCE Left

MAGN. MEASURE Horiz

DATE MEASURED

MEASURED BY

NOTES

Photo Corr 1.768

RDM

HORIZONTAL GRID CELL

VERTICAL GRID CELL	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
1																
2																
3		.542	.417	.182	.096	.093	.066	.063	.045	.045	.041	.033				
4		.549	.415	.173	.116	.087	.066	.063	.051	.047	.046	.038	.036			
5		.561	.406	.199	.131	.107	.082	.073	.070	.060	.052	.051	.039			
6								.078	.077	.067	.055	.054	.042			
7																
8																

MAGNIFICATION RECORDING FORM (M-1)

DEVICE DESCRIPTION Non Spher (v)

DEVICE DIMENSIONS 6.5x40

EYE REFERENCE Right

MAGN. MEASURE Horiz.

DATE MEASURED

MEASURED BY

NOTES

P/C 1.768

RDM

HORIZONTAL GRID CELL

VERTICAL GRID CELL	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
1																
2																
3	–	.559	.260	.160	.111	.135	.068	.061	.048	.045	.041	.033				
4	.522	.575	.277	.150	.102	.135	.071	.059	.048	.050	.039	.038				
5	–	.584	.270	.171	.131	.111	.077	.073	.068	.055	.052	.043				
6								.085	.084	.073	.055	.054				
7																
8																

MAGNIFICATION RECORDING FORM (M-1)

DEVICE DESCRIPTION Non Spher(V)

DEVICE DIMENSIONS 6.5x4

EYE REFERENCE Right

MAGN. MEASURE Vert

DATE MEASURED

MEASURED BY

NOTES

Photo Corr 1.768

RDM

HORIZONTAL GRID CELL

VERTICAL GRID CELL

	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
1																
2																
3																
4	.594	.607	.607	.544	.505	.481	.439	.442	.411	.398	.385	.381				
5					.487	.404	.434	.418	.406	.398	.408					
6											.392					
7																
8																

MAGNIFICATION RECORDING FORM (M-1)

DEVICE DESCRIPTION Non Spher (V)

DEVICE DIMENSIONS 6.5Y 4.0

EYE REFERENCE LEFT

MAGN. MEASURE Verticle

DATE MEASURED

MEASURED BY

NOTES

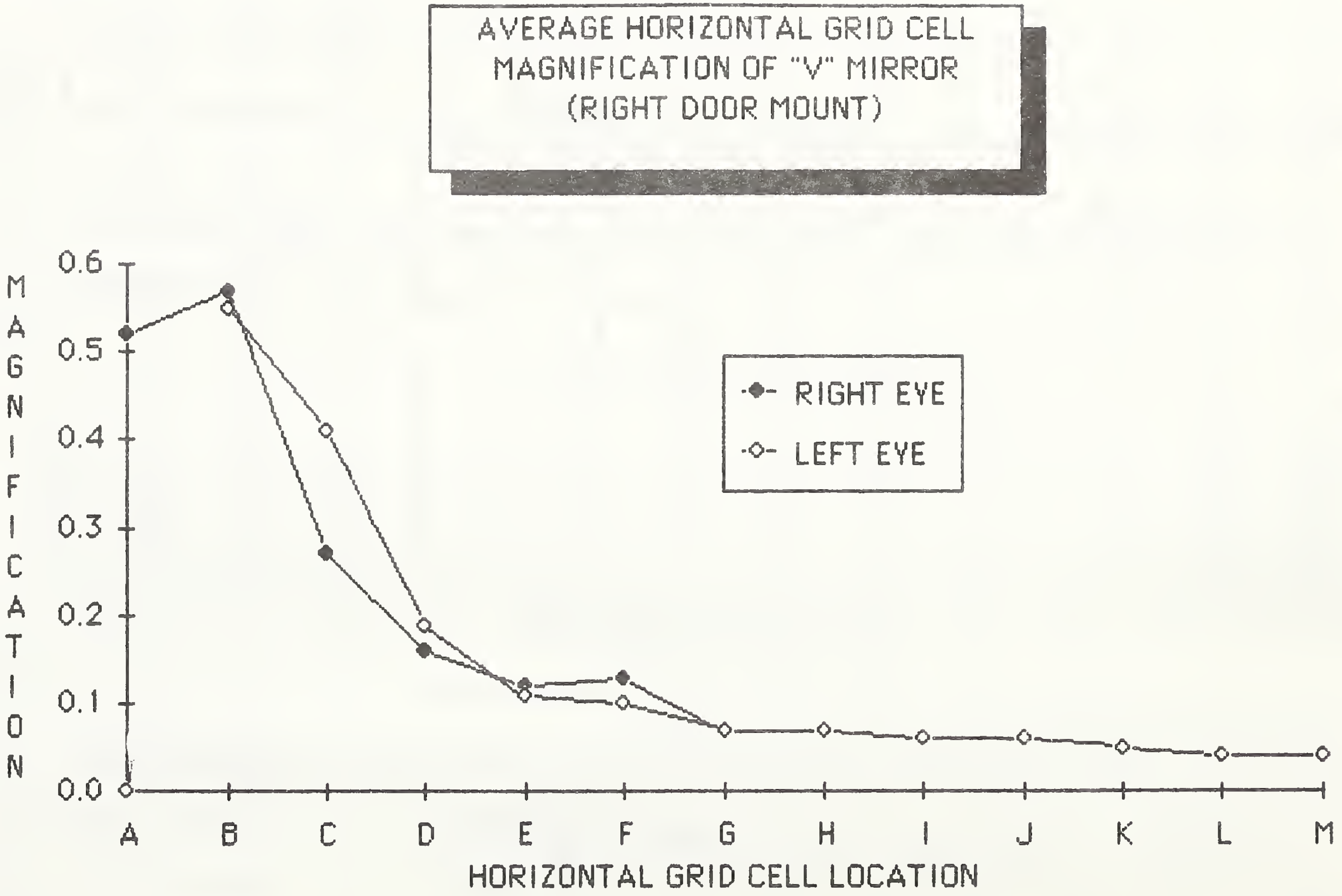
P/C 1.768

RDM

HORIZONTAL GRID CELL

VERTICAL GRID CELL

	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
1																
2																
3																
4		.605	.636	.574	.524	.499	.461	.428	.414	.409	.400	.397				
5					.524	.486	.455	.454	.420	.398	.406	.400				
6											.395	.381				
7																
8																


AVERAGE HORIZONTAL GRID CELL
MAGNIFICATION OF "V" MIRROR
(RIGHT DOOR MOUNT)
RIGHT EYE
LEFT EYE
MAGNIFICATION
0.6
0.5
0.4
0.3
0.2
0.1
0.0
A
B
C
D
E
F
G
H
I
J
K
L
M
HORIZONTAL GRID CELL LOCATION

A-4 DEVICE; 3.5 X 6.5 INCH NON-SPHERICAL/CURVED (Z) MIRROR

A-4.1 LOCATION; LEFT DOOR MOUNT

A. GRID PHOTOS

1. LEFT EYE
2. RIGHT EYE

B. FIELD OF VIEW

1. LEFT EYE/RIGHT EYE
    a. horizontal
    b. vertical

C. MAGNIFICATION

1. HORIZONTAL
    a. left eye
    b. right eye

2. VERTICAL
    a. left eye
    b. right eye

D. RADIUS OF CURVATURE

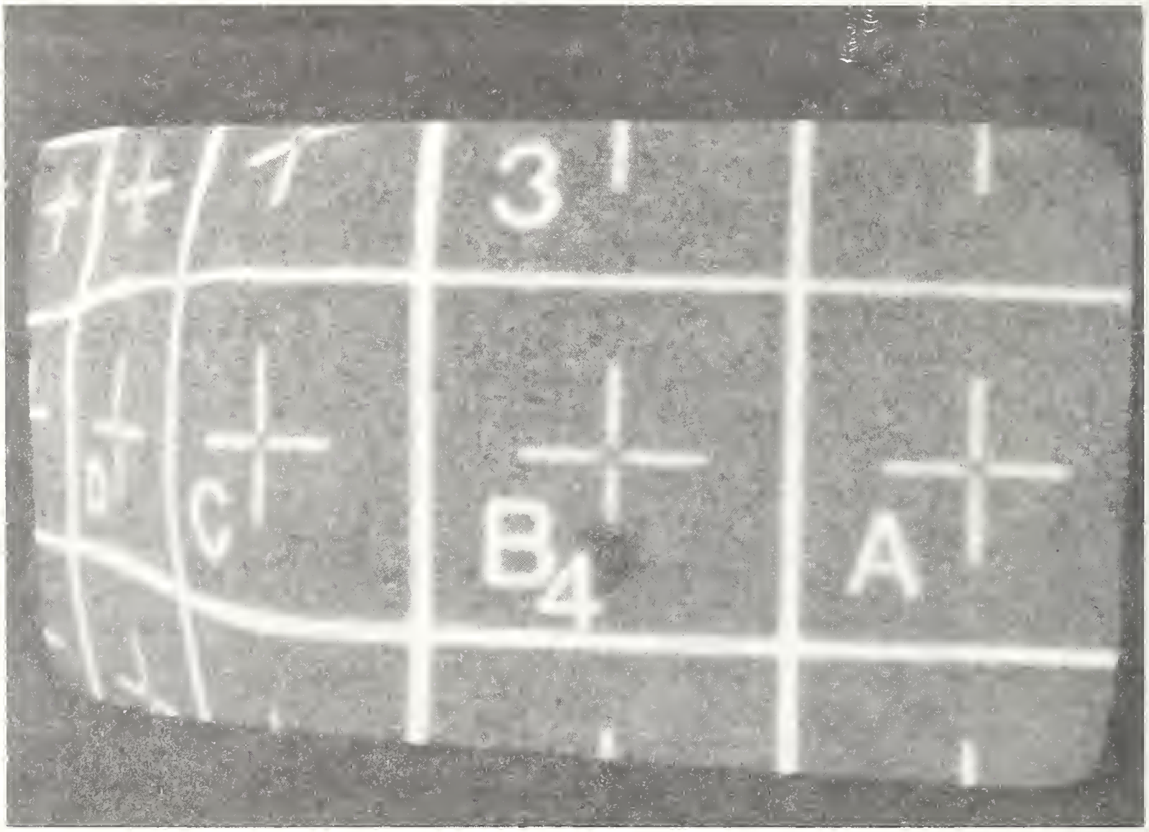
1. HORIZONTAL

2. VERTICAL

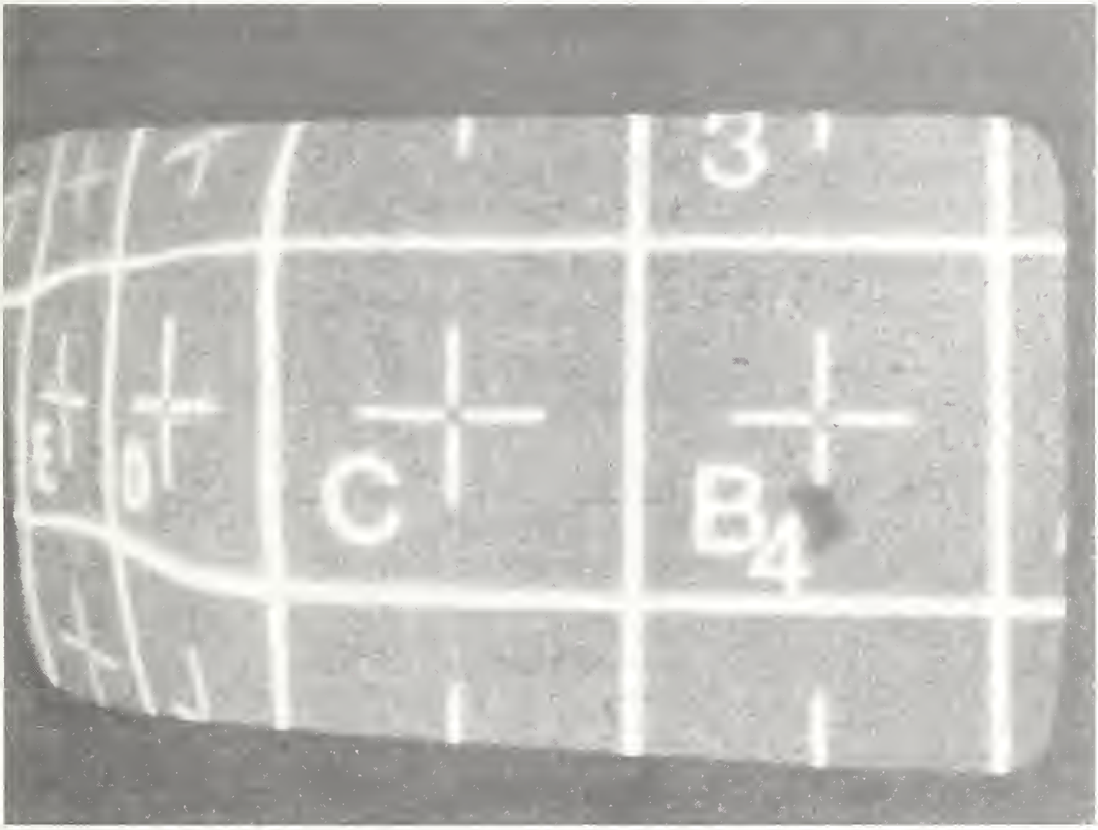
E. ACCOMMODATION DISTANCE

F. REFLECTANCE

GRID PHOTO, NON-SPHERICAL/CURVED MIRROR (Z),
LEFT DOOR MOUNT, LEFT EYE

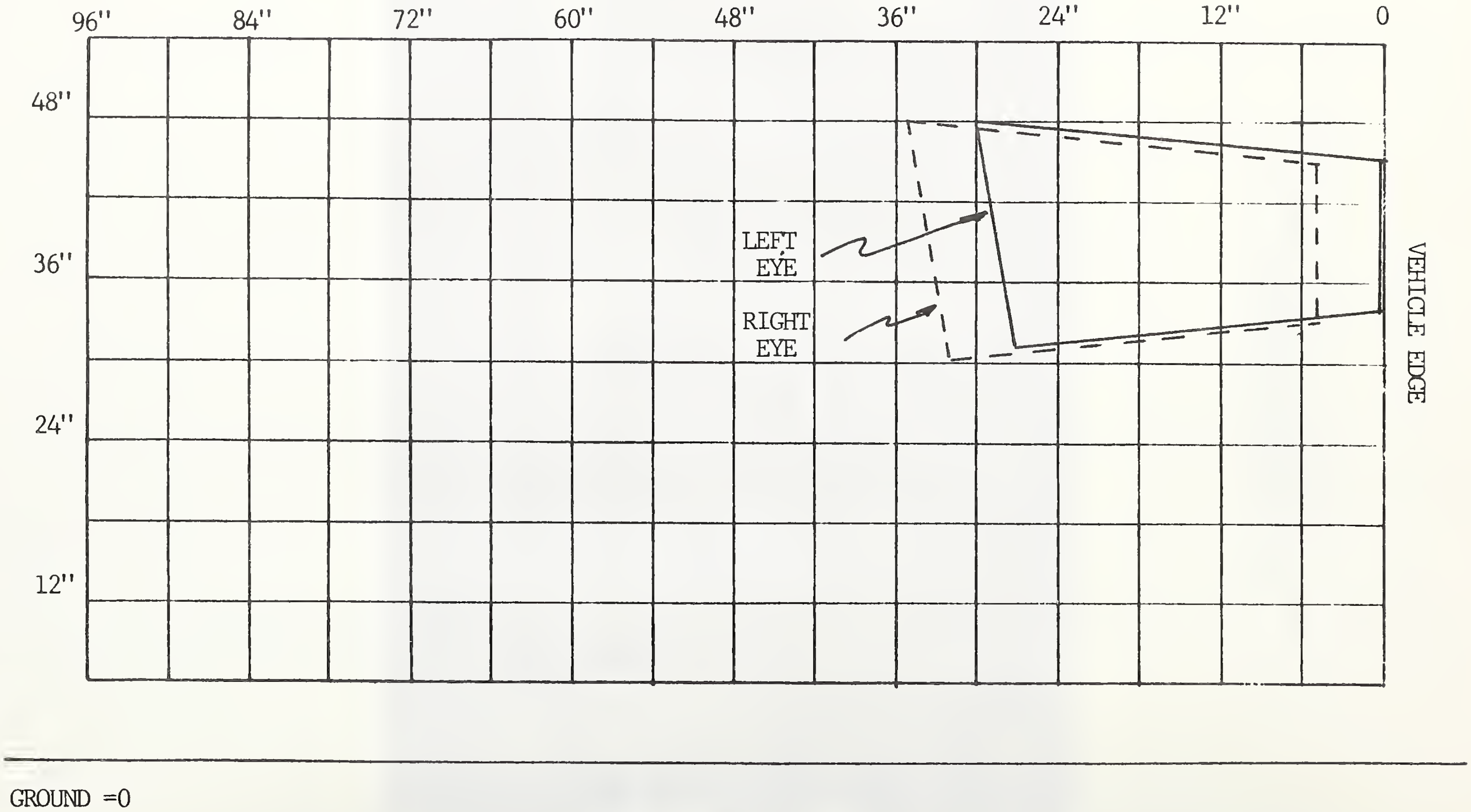


GRID PHOTO, NON-SPHERICAL/CURVED MIRROR (Z),
LEFT DOOR MOUNT, RIGHT EYE



]

NON-SPHERICAL/CURVED (Z) MIRROR FOV, LEFT DOOR MOUNT (LEFT AND RIGHT EYE)



SCALE: 1''=1'

MAGNIFICATION RECORDING FORM

DEVICE DESCRIPTION Non-Spherical/Curved (Z)

DEVICE DIMENSIONS 6.5 x 3.5 in.

EYE REFERENCE Left

MAGN. MEASURE Horizontal

DATE MEASURED

MEASURED BY

NOTES Horizontal Magnification
For Left Eye

Left Door Mount

HORIZONTAL GRID CELL

VERTICAL GRID CELL	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
1																
2																
3													.27	.58	.97	
4													.26	.65	.97	.97
5													.32	.54	.97	
6																
7																
8										$\overline{X}$			.28	.59	.97	.97

FOV

MAGNIFICATION RECORDING FORM

DEVICE DESCRIPTION Non-Spherical/Curved (Z)
DEVICE DIMENSIONS 6.5 X 3.5 IN.
EYE REFERENCE Right
MAGN. MEASURE Horizontal
DATE MEASURED
MEASURED BY

NOTES Horizontal Magnification
For Right Eye

Left Door Mount

HORIZONTAL GRID CELL

VERTICAL GRID CELL

	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
1																
2																
3												.22	.47			
4												.25	.45	.95	.98	
5												.35				
6																
7																
8									$\overline{X}$			.27	.46	.95	.98	

FOV

MAGNIFICATION RECORDING FORM

DEVICE DESCRIPTION Non-Spherical/Curved (B)

DEVICE DIMENSIONS 6.5 X 3.5 in.

EYE REFERENCE Left

MAGN. MEASURE Vertical

DATE MEASURED

MEASURED BY

NOTES Vertical Magnification for Left Eye

Left Door Mount

HORIZONTAL GRID CELL

VERTICAL GRID CELL

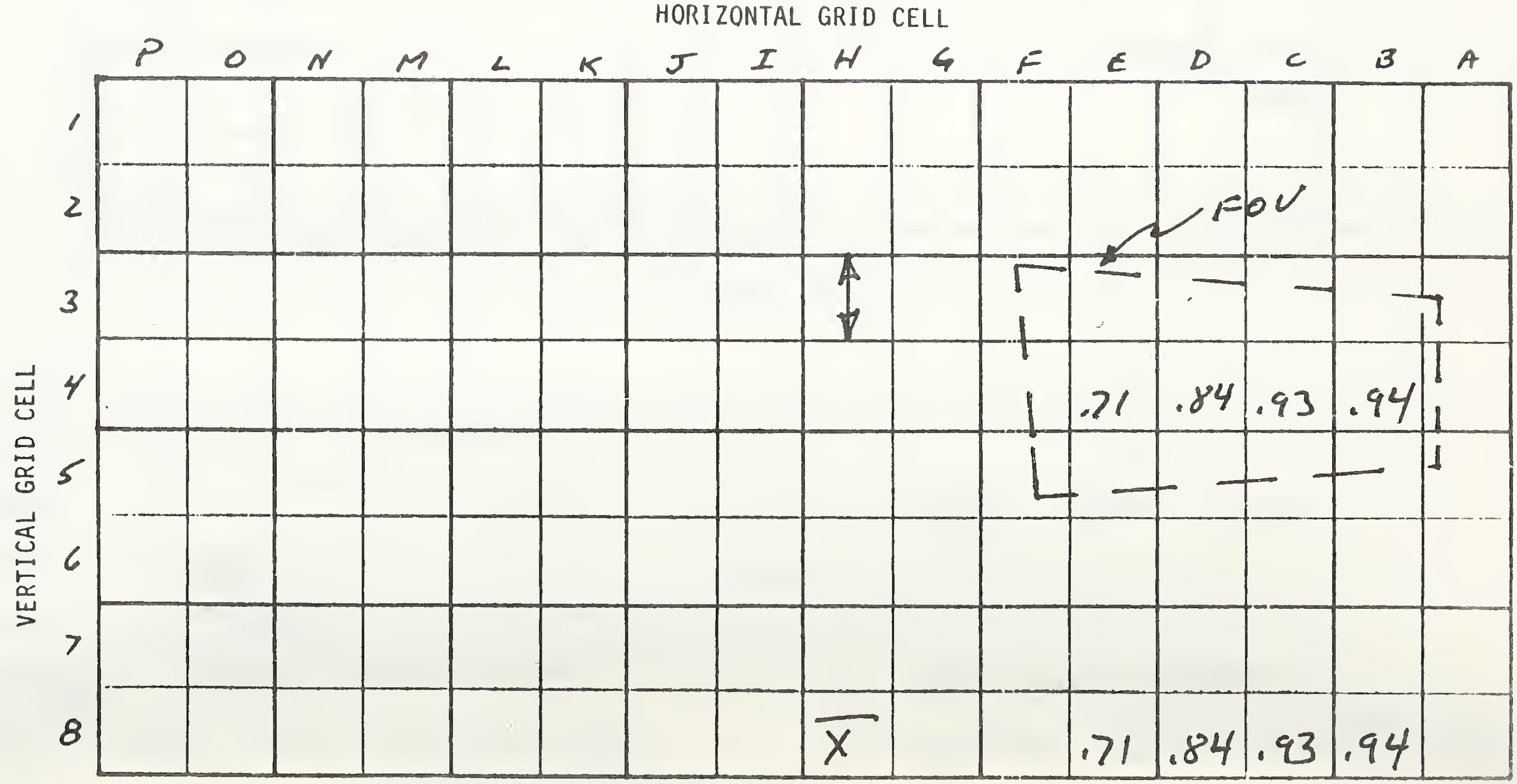
	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
1																
2														FOV		
3												.51	.46			
4												.62	.74	.89	.93	.93
5																
6																
7																
8										$\overline{X}$		.57	.60	.89	.93	.93

MAGNIFICATION RECORDING FORM

DEVICE DESCRIPTION Non-Spherical/Curved (Z)
DEVICE DIMENSIONS 6.5X3.5 in.
EYE REFERENCE Right
MAGN. MEASURE Vertical
DATE MEASURED
MEASURED BY

NOTES Vertical Magnification
for Right Eye

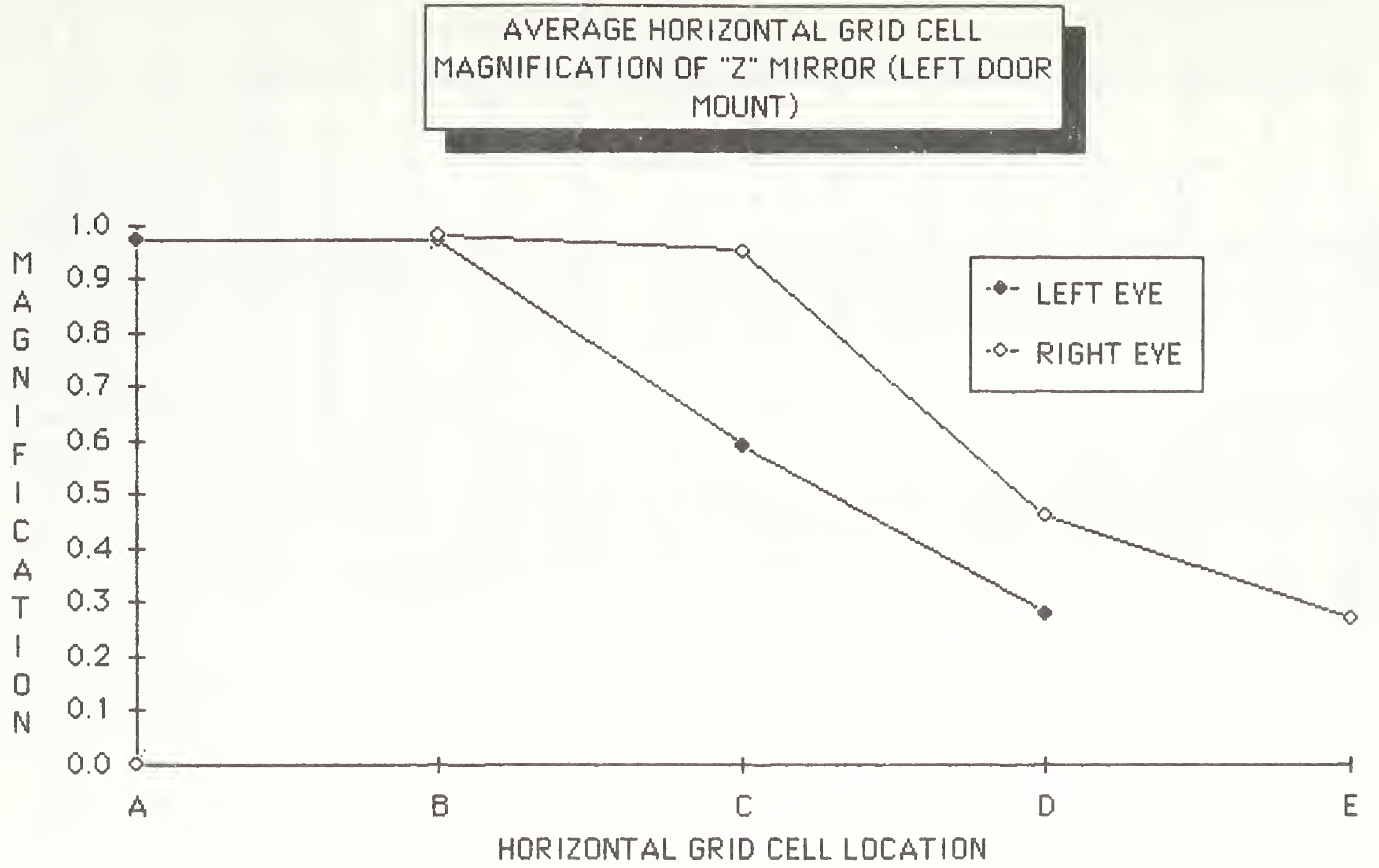
Left Door Mount



HORIZONTAL GRID CELL

VERTICAL GRID CELL

	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
1																
2																
3																
4												.71	.84	.93	.94	
5																
6																
7																
8									$\overline{X}$			.71	.84	.93	.94	


AVERAGE HORIZONTAL GRID CELL MAGNIFICATION OF "Z" MIRROR (LEFT DOOR MOUNT)
LEFT EYE
RIGHT EYE
MAGNIFICATION
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
A
B
C
D
E
HORIZONTAL GRID CELL LOCATION

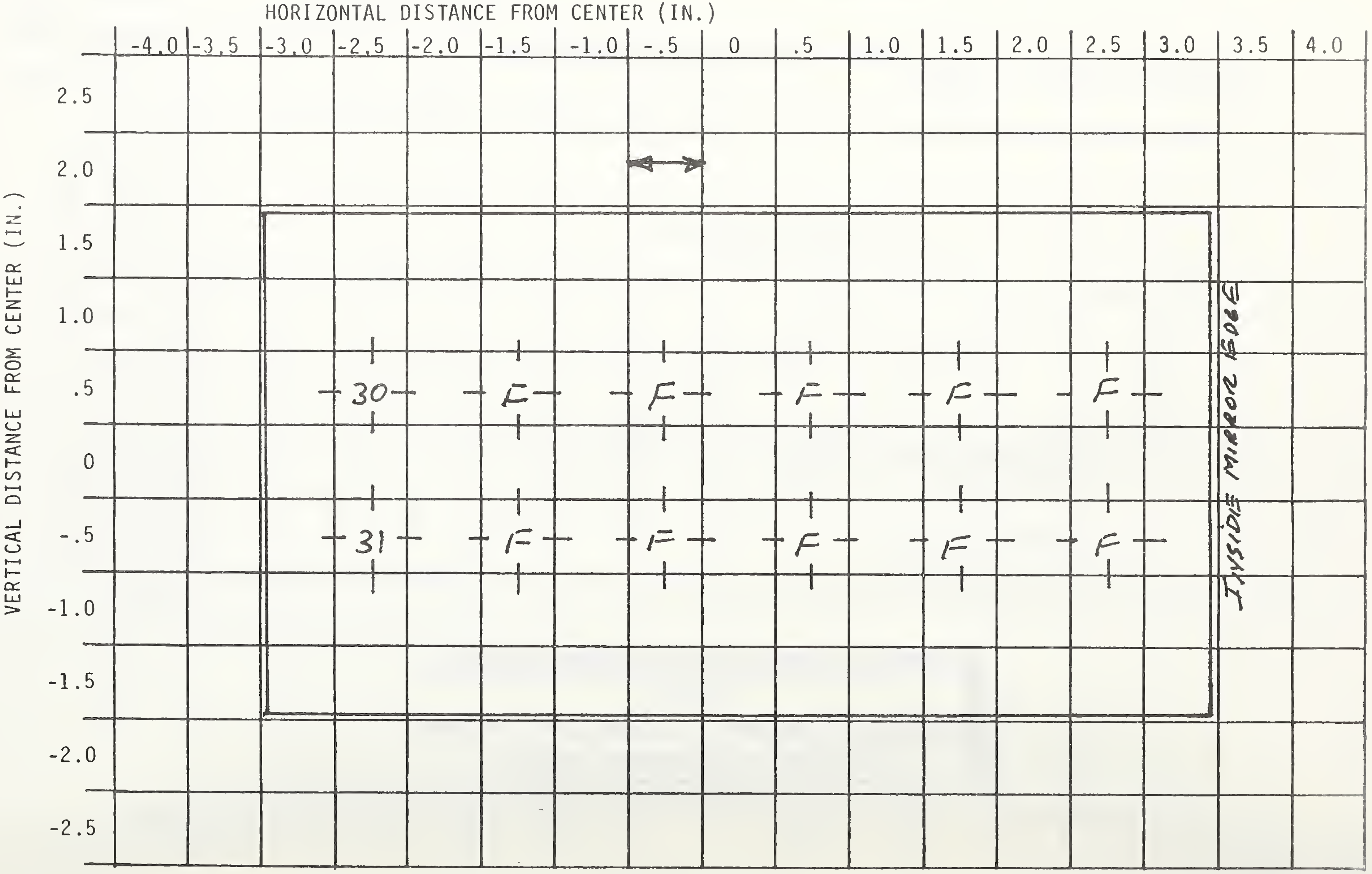
RADIUS OF CURVATURE MEASUREMENT FORM

DEVICE NON-SPHERICAL/CURVED (B)

MEASURED BY

MEASUREMENT HORIZONTAL ROC (IN.)

DATE



RADIUS OF CURVATURE MEASUREMENT FORM

DEVICE Non-Spherical Curved (Z)

MEASUREMENT Vertical ROC (in.)

MEASURED BY

DATE

HORIZONTAL DISTANCE FROM CENTER (IN.)

VERTICAL DISTANCE FROM CENTER (IN.)

	-4.0	-3.5	-3.0	-2.5	-2.0	-1.5	-1.0	-.5	0	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
2.5																	
2.0																	
1.5																	
1.0					34	100	F		F		F		F				
.5																	
0					42	120	F		F		F		F				
-.5																	
-1.0					35	120	F		F		F		F				
-1.5																	
-2.0																	
-2.5																	

INSIDE MIRROR EDGE

A-4.2 LOCATION; RIGHT DOOR MOUNT

A. GRID PHOTOS

1. LEFT EYE
2. RIGHT EYE

B. FIELD OF VIEW

1. LEFT EYE/RIGHT EYE
   a. horizontal
   b. vertical

C. MAGNIFICATION

1. HORIZONTAL
   a. right eye
   b. left eye

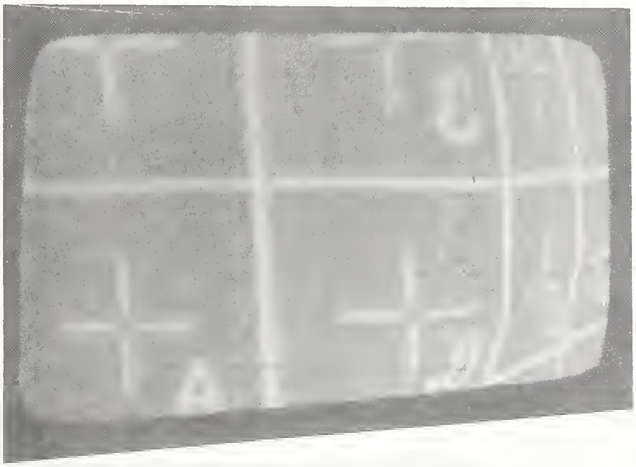
2. VERTICAL
   a. right eye
   b. left eye

D. RADIUS OF CURVATURE
(See left door mount data)

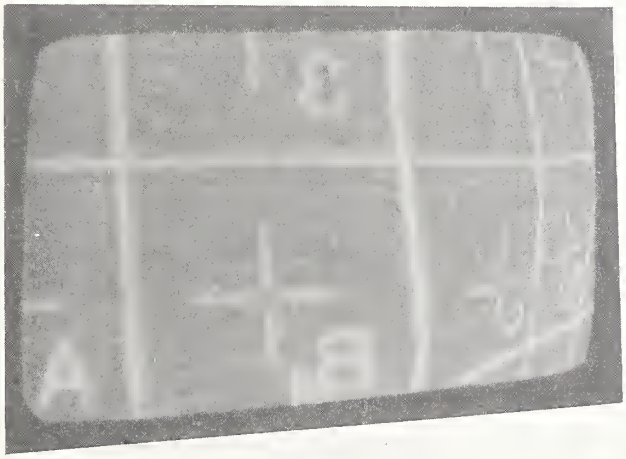
E. ACCOMMODATION DISTANCE

F. REFLECTANCE
(See left door mount data)

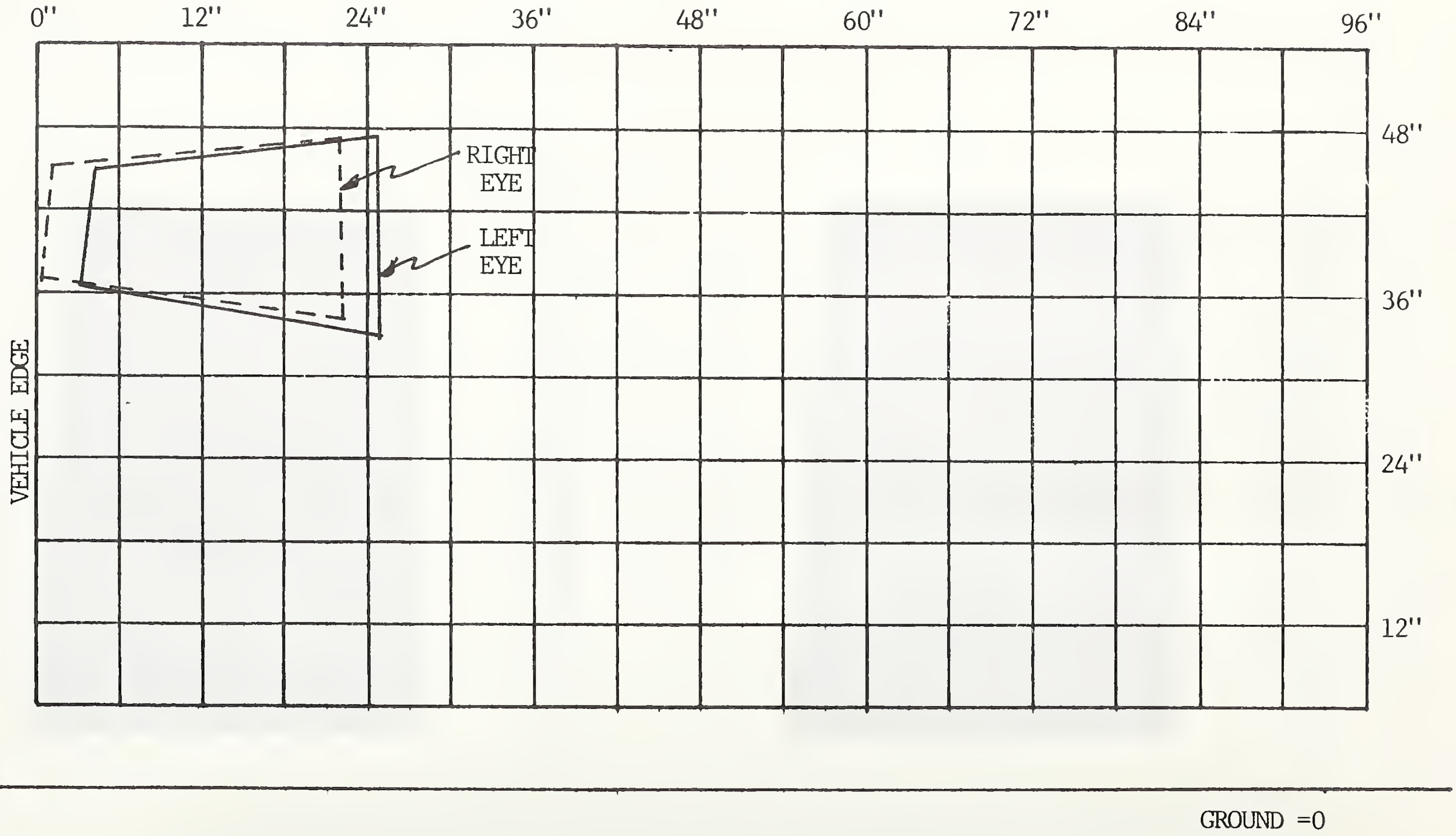
GRID PHOTO, NON-SPHERICAL/CURVED (Z) MIRROR,
RIGHT DOOR MOUNT, RIGHT EYE



GRID PHOTO, NON-SPHERICAL/CURVED (Z) MIRROR,
RIGHT DOOR MOUNT, LEFT EYE



NON-SPHERICAL/CURVED (Z) MIRROR FOV,
RIGHT DOOR MOUNT (RIGHT AND LEFT EYE)



SCALE 1''=1'

MAGNIFICATION RECORDING FORM (M-1)

DEVICE DESCRIPTION MON SPHER(2)

DEVICE DIMENSIONS

EYE REFERENCE RT

MAGN. MEASURE HORIZ

DATE MEASURED

MEASURED BY

NOTES P/C 1.838

RDM

HORIZONTAL GRID CELL

VERTICAL GRID CELL	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
1																
2																
3	1.024	.849	.313	.131												
4	1.024	.853	.259	.111												
5																
6																
7																
8																

MAGNIFICATION RECORDING FORM (M-1)

DEVICE DESCRIPTION NON SPHER(Z)

DEVICE DIMENSIONS

EYE REFERENCE LEFT

MAGN. MEASURE HORIZ

DATE MEASURED

MEASURED BY

NOTES

P/C 1,776

RDM

HORIZONTAL GRID CELL

VERTICAL GRID CELL

	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
1																
2																
3		.967	.463	.234												
4		.994	.416	.215												
5																
6																
7																
8																

MAGNIFICATION RECORDING FORM (M-1)

DEVICE DESCRIPTION Non Spher(2)

DEVICE DIMENSIONS

EYE REFERENCE Right

MAGN. MEASURE Vertical

DATE MEASURED

MEASURED BY

NOTES P/C 1.838

RDM

HORIZONTAL GRID CELL

VERTICAL GRID CELL	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
1																
2																
3	1.067	1.048	.427	.664												
4	.940	.805	.653	.548												
5																
6																
7																
8																

MAGNIFICATION RECORDING FORM (M-1)

DEVICE DESCRIPTION NON SPHER(2)

DEVICE DIMENSIONS

EYE REFERENCE LEFT

MAGN. MEASURE VERT

DATE MEASURED

MEASURED BY

NOTES

P/C 1.776

RDM

HORIZONTAL GRID CELL

VERTICAL GRID CELL	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
1																
2																
3			.925	.686												
4	.977	.967	.710	.643												
5																
6																
7																
8																

A-5 DEVICE; 4.4 X 6.6 INCH 20 INCH ROC CONVEX MIRROR

A-5.1 LOCATION; RIGHT DOOR MOUNT

A. GRID PHOTOS

1. RIGHT EYE
2. LEFT EYE

B. FIELD OF VIEW

1. RIGHT EYE/LEFT EYE
    a. horizontal
    b. vertical

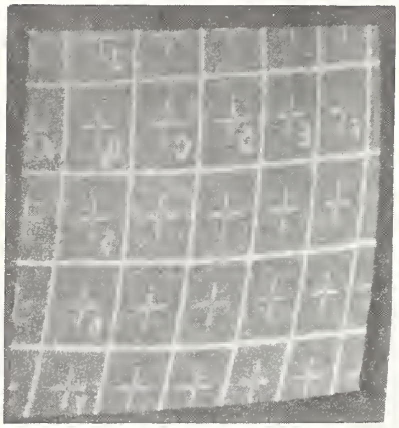
C. MAGNIFICATION

1. HORIZONTAL
    a. right eye
    b. left eye

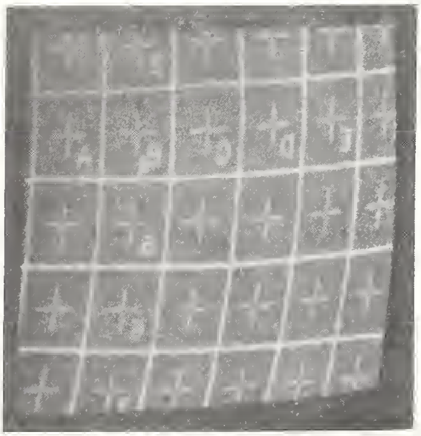
2. VERTICAL
    a. right eye
    b. left eye

GRID PHOTO 20 INCH ROC SPHERICAL CONVEX MIRROR,
RIGHT AND LEFT EYE, RIGHT DOOR MOUNT

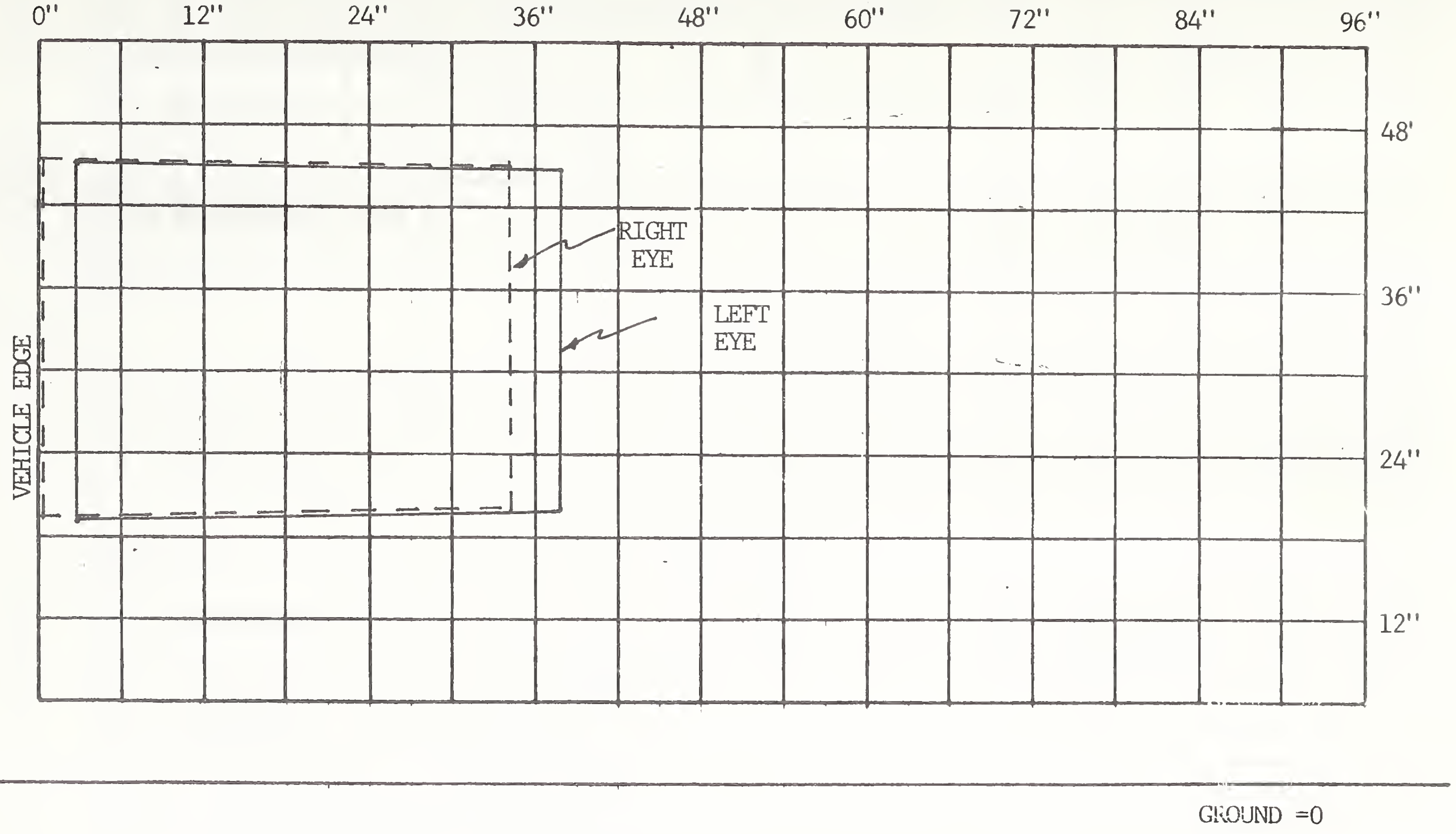
RIGHT EYE



LEFT EYE



20 INCH ROC SPHERICAL CONVEX MIRROR FOV,
RIGHT DOOR MOUNT (RIGHT AND LEFT EYE)



SCALE 1''=1'

MAGNIFICATION RECORDING FORM (M-1)

DEVICE DESCRIPTION Convex 20"
DEVICE DIMENSIONS 6.6 x 4.4
EYE REFERENCE Right
MAGN. MEASURE Horiz
DATE MEASURED
MEASURED BY

NOTES P/C 1.808

RDM

HORIZONTAL GRID CELL

VERTICAL GRID CELL	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
1																
2																
3	.254	.253	.242	.231	.205											
4	.239	.253	.251	.225	.214											
5	.248	.251	.246	.231	.211											
6	.241	.249	236	.277	.216											
7		.244	.236	.225	.220											
8																

MAGNIFICATION RECORDING FORM (M-1)

DEVICE DESCRIPTION CONVEX 20"
DEVICE DIMENSIONS 6.6 x 4.4
EYE REFERENCE LEFT
MAGN. MEASURE HORIZ
DATE MEASURED
MEASURED BY

NOTES
P/C 1.808
RDM

HORIZONTAL GRID CELL

VERTICAL GRID CELL

	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
1																
2																
3		.253	.238	.277	—	-										
4		.244	.238	.231	.207	.194										
5		.244	.238	.231	.207	.196										
6		.246	.236	.223	.207	.189										
7		.240	.234	.223	.207	.203										
8																

MAGNIFICATION RECORDING FORM (M-1)

DEVICE DESCRIPTION CONVEX 20"

DEVICE DIMENSIONS 6.6 x 4.4

EYE REFERENCE RIGHT

MAGN. MEASURE VERTICAL

DATE MEASURED

MEASURED BY

NOTES P/C 1.408

RDM

HORIZONTAL GRID CELL

VERTICAL GRID CELL	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
1																
2																
3																
4	.307	.327	.336	.332	.342	.346										
5	.316	.317	.319	.330	.334	.340										
6	.297	.304	.302	.314	.325	.330										
7																
8																

MAGNIFICATION RECORDING FORM (M-1)

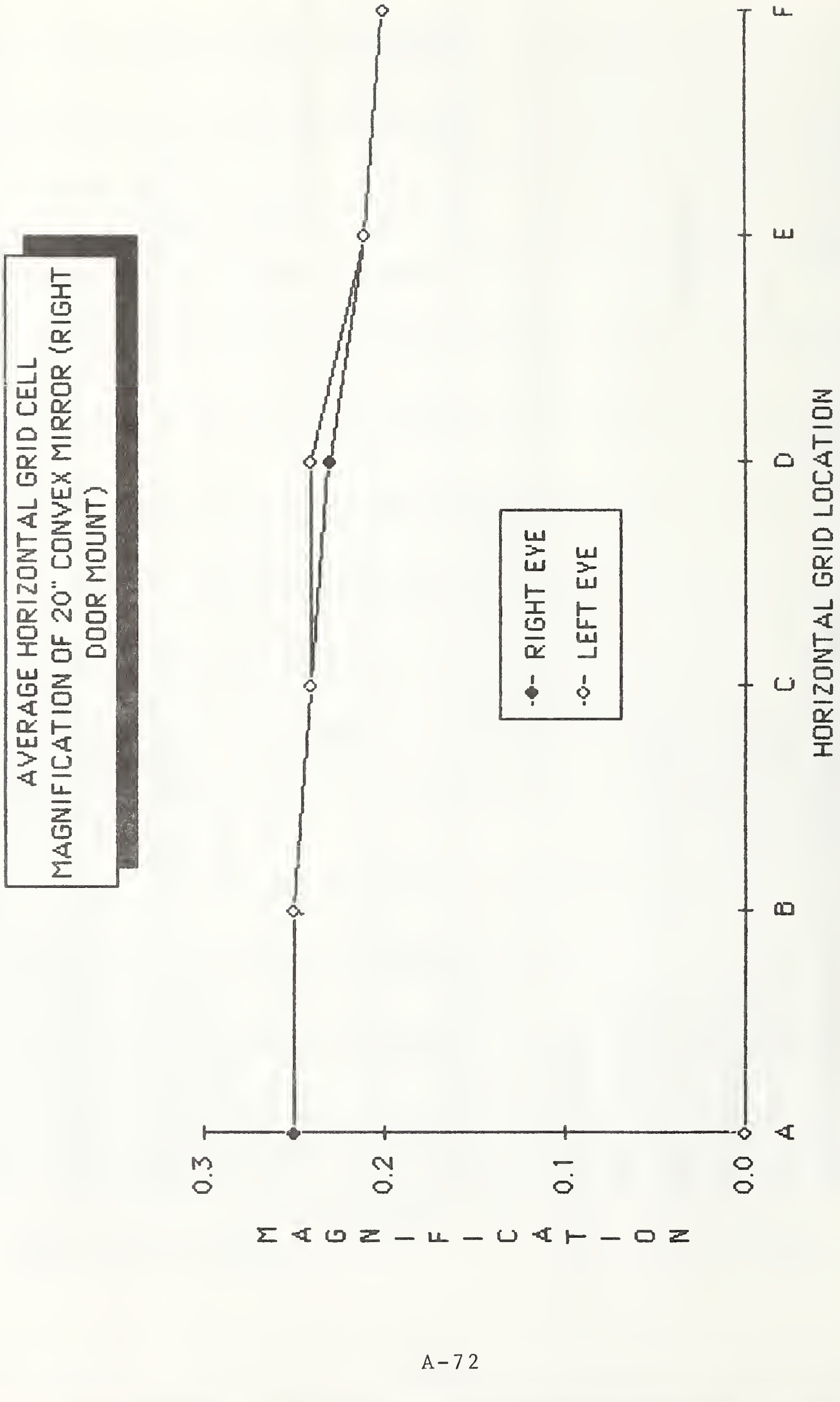
DEVICE DESCRIPTION Convex 20''
DEVICE DIMENSIONS 6.6 x 4.4
EYE REFERENCE LEFT
MAGN. MEASURE Vertical
DATE MEASURED
MEASURED BY

NOTES P/C 1.808
RDM

HORIZONTAL GRID CELL

VERTICAL GRID CELL

	P	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
1																
2																
3																
4	.314	.321	.338	.347	.340	.346										
5	.316	.325	.321	.336	.350	.349										
6	—	.314	.308	.323	.332	.335										
7																
8																


AVERAGE HORIZONTAL GRID CELL MAGNIFICATION OF 20" CONVEX MIRROR (RIGHT DOOR MOUNT)
MAGNIFICATION
0.3
0.2
0.1
0.0
A
B
C
D
E
F
HORIZONTAL GRID LOCATION
● RIGHT EYE
◇ LEFT EYE

A-6 DEVICE; 4.1 X 3.7 INCH PLANE/2.0 X 3.7 INCH 10 INCH ROC CONVEX (K) MIRROR

A-6.1 LOCATION; RIGHT DOOR MOUNT

A. GRID PHOTOS

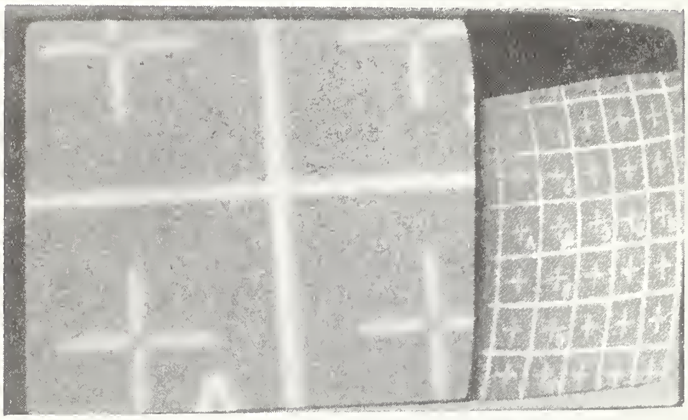
1. RIGHT EYE
2. LEFT EYE

B. FIELD OF VIEW

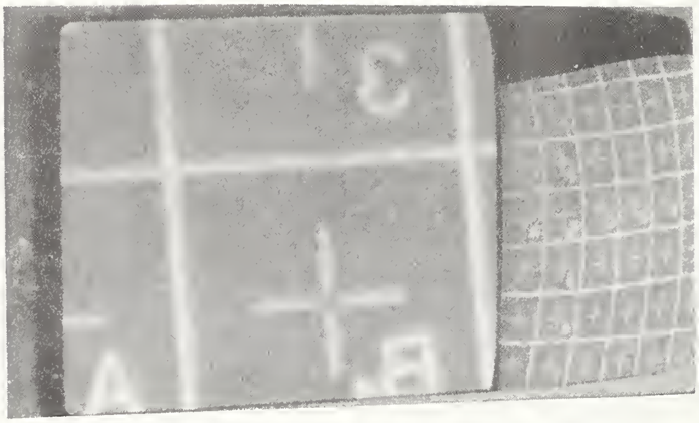
1. LEFT EYE/RIGHT EYE
    a. horizontal
    b. vertical

GRID PHOTO, PLANE/10 INCH ROC SPHERICAL CONVEX (K) MIRROR, RIGHT AND LEFT EYE, RIGHT DOOR MOUNT

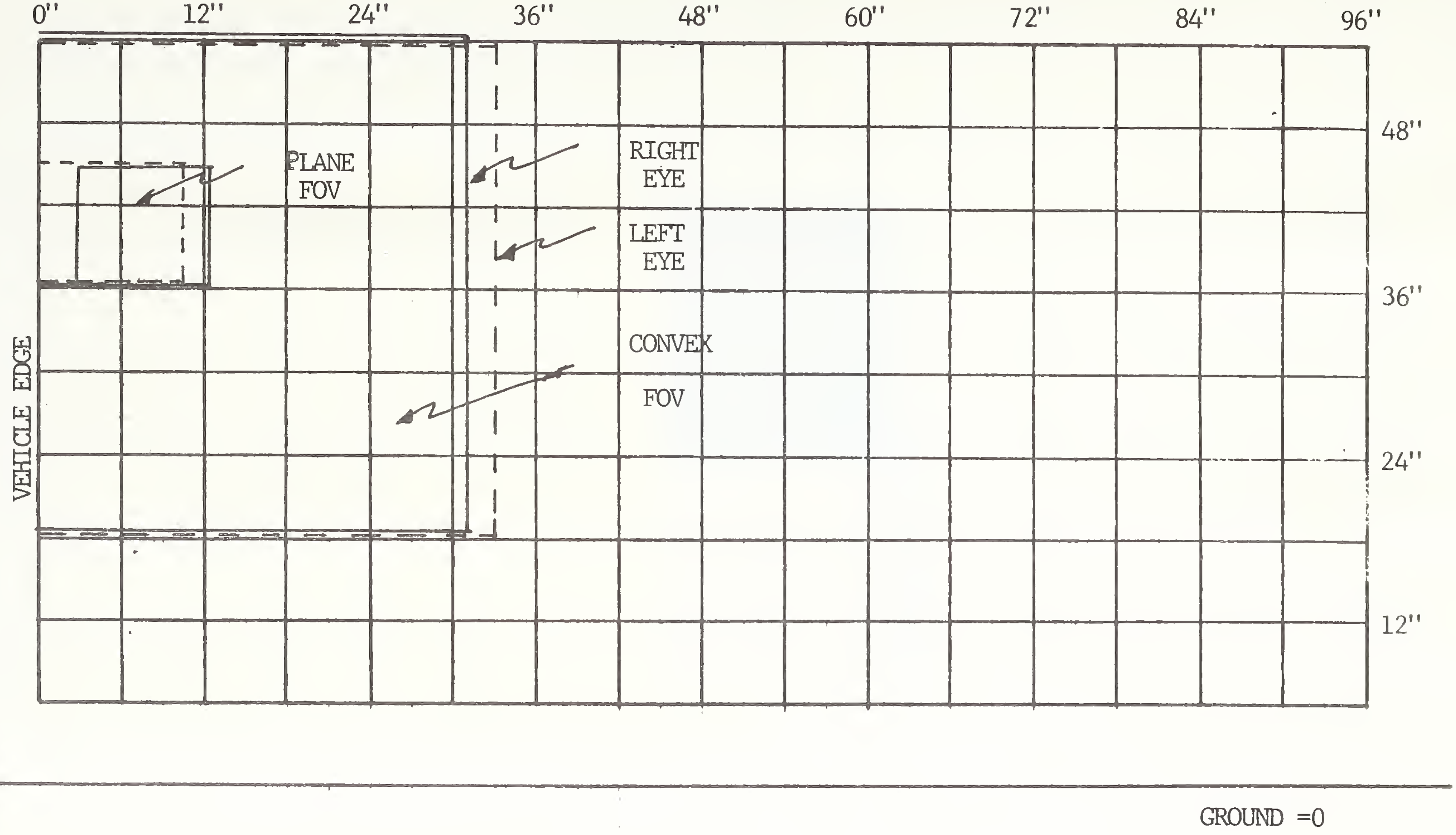
RIGHT EYE



LEFT EYE



PLANE 10 INCH ROC SPHERICAL (K) MIRROR FOV,
RIGHT DOOR MOUNT (RIGHT AND LEFT EYE)



SCALE 1''=1'

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